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THE

AMERICAN JOURNAL OF SCIENCE.

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THIRD SERIES.

VOL. XLVII.—[WHOLE NUMBER, CXLVII.]

No. 282.—JUNE, 1894.

NEW HAVEN, CONN.: J. D. & E. S. DANA.

1894.

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS, 371 STATE STREET.

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THE

AMERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

ART. XLIX.—*Notes from the Bermudas;* by ALEXANDER AGASSIZ.*

. . . . Before completing my article on the Bahamas I was anxious to visit the Bermudas. I have spent about a month in their examination and find that the story of their present condition is practically that of the Bahamas, with the exception that at the Bermudas we have an epitome as it were of the physical changes undergone by the Bahamas. One cannot fail to be struck with the insignificance of the corals as compared with those of Florida, of the Bahamas and of the Windward islands. It is true that on the ledge patches inside of the so-called "ledge-flats" the Gorgonians and Millepores are very flourishing, but the development of the true reef builders, of the massive corals, is insignificant; while the absence of Madrepores is remarkable and changes the whole aspect of the coral growth.

I shall have little to add to the description of the Bermudas as given by Nelson, Rein, Thomson, Rice and Heilprin, but I am inclined to take a different view of the part which the corals now growing have played in the formation of the reef ledge flats. The corals have not added any material part to the reefs, they form only a thin veneer over the disintegrated ledges of æolian rocks which constitute the so-called reef off the south shore of Bermuda and the ledge flats of the outer reef ring near the edge of the Bermuda Bank. Æolian rock ledges underlie the growth of corals not only on the patches off the south shore and on the ledge flats of the outer reef but they

* From a letter to Professor James D. Dana, dated Bermuda, March 12th, 1894.

also underlie the so-called patches and heads forming the flats which extend on both sides of the main channel and divide the interior waters of the Bank into irregular sounds like Murray anchorage. The passage of the shore æolian rock ledges into the coral patches can easily be traced both off the north and south shores.

I fully agree with those who before me have examined the Bermudas and who consider that subsidence has brought about the existing outlines of the islands. But that is a very different thing from assigning to the corals now growing the formation of the islands owing to this subsidence. That the protobermudian land was of elliptical shape and owed its existence to the action of winds sweeping over an extensive coral beach from which was gathered the materials which now form the solidified æolian hills of Bermudas no one can question. But there is no evidence to show that the original annular coral reef was formed during subsidence. That reef has disappeared and nothing is left of it except the remnants of the æolian ledges extending to 16 or 17 fathoms outside of the reef ledge flats, ledges which owed their existence to the material derived from it: the former æolian hills of the protobermudian land. Remnants of such ledges and former æolian hills are the rocks forming the outer ledge flats, the breakers all along the south shore, the Mills breaker, the North Rocks, the Chub-heads, the South-west breaker and others.

The Bermudas and Bahamas offer an example of the thickness of a recent limestone deposit during a period of rest. Assuming a probable subsidence of 70 feet and a greatest elevation of 260 feet we get a coral limestone of 330 feet in thickness, the material of which has all come from a reef which itself was probably not thicker than 120 feet or a total thickness of 450 feet. In the case of the Bahamas the maximum height of the æolian hills is stated to be about 400 feet and the greatest subsidence was probably as much as 200 feet which with the thickness of the reef would give a thickness of 720 feet of coral limestone. This thickness or a great part of it moreover is not limited to a circumscribed area but extends, as is the case of the Bahamas, over a wide region. When we remember how readily these coral limestones are changed into hard ringing rocks we introduce a new element into the discussion of the mode of formation of huge masses of limestone especially in the region of the trade winds.

Solution has undoubtedly played some part in producing the fantastic outlines of the limestone ledges as well as of the shore rocks below low-water mark but the solvent action of the salt water cannot be compared in efficiency to the destructive mechanical action of the sea. This has to a great extent been

arrested by the covering coat of Gorgonians, Millepores, Algæ, and Corallines as well as of the more massive corals found thriving upon the heads, patches, ledges and ledge flats of the inner and outer waters of the Bermudas. But these heads, ledges, etc. do not as has been stated by former observers, owe their existence and their gradual increase to the corals, as they only form a protecting veneer over their surface, viz: a coral growth and not a coral reef.

The so-called Serpulæ reefs described before by previous observers, are perhaps the most interesting structures of the Bermuda reefs. They are most numerous off the south shore, constituting miniature atolls, barrier and fringing reefs apparently formed by the upward growth of Serpulæ. While Serpulæ undoubtedly cover a great part of the surface of the structures, yet Algæ, Corallines, barnacles, mussels and other invertebrates are found to be fully as abundant as the Serpulæ which in many cases play a secondary part. In fact it would be as correct in some localities to call them Algæ or Coralline atolls. Neither the Serpulæ nor the Algæ or other organisms have built up to any considerable extent the vertical walls of the different kinds of diminutive reefs so characteristic of the south shore. The Serpulæ, Algæ, Corallines and other growths have only protected the surface of the æolian rock ledges which form these structures from the action of the breakers. They have not built up the raised rims of the atolls, of the crescent or of the horseshoe-shaped reefs, or the vertical walls forming the irregular convolutions and curves of the broader ledges.

All these structures from a circular or elliptical atoll to a barrier or fringing reef with all their possible modifications, are due to the action of the surf and the wash of the sea in eating away the surface of the mushroom-shaped rocks which is either softer than the surrounding parts or is not protected by the covering coat of Algæ, Corallines or Serpulæ. One can off the south shore trace the whole process from the time when the large fragments of shore æolian rocks fall by undermining into the sea, until they are changed by the action of the surf into mushroom-shaped ledges surmounted by pinnacles, next into the stage when the pinnacle has in its turn been undermined and dropped alongside of the ledge to become the holding ground of coral and other growth. The surface of the flat ledge which formed the base of the pinnacle is now freely acted upon by the breakers. According to the nature of the upper crust and to the extent of protection given to it by the covering coat of animal and vegetable life the sea acts upon it and we have hollowed out atolls of diminutive size, crescent or horseshoe-shaped structures as well as the curved, straight

or convoluted or looped vertical walls of broader ledges which stand up from the bottom and seem to have been built up by the organisms covering their surface. Taking this for granted as had been done by previous observers, I was greatly surprised on hammering at some of these structures, to find the vertical walls composed of æolian rocks and to discover that in many cases the elevated rim was protected by the hard ringing crust so characteristic of limestones exposed to the action of the sea, and further to find that the coating of Serpulæ, of Algæ, of Corallines and Nullipores was quite superficial. It soon became evident that these diminutive atolls were large pot holes excavated by the surf and sand and that the varied forms of crescent-shaped reef of barrier reefs and all the possible modifications one finds on the south shore of the Bermuda are all due to the mechanical action of the surf.

The following diagrams will explain their mode of formation better than any lengthy description I can give.

AB (fig. 1) is a piece of shore cliff which has become isolated, the æolian lamination is clearly seen above high water mark. Below high water mark it is honeycombed and eaten away, leaving the æolian pinnacle supported only by a slender stem rising from an extensive base more or less covered with Algæ, Serpulæ and other growth. The surface of the ledge as well as the base of the mass extending below low water mark is more or less eaten away and when the æolian pinnacle (A) has fallen off a mushroom-shaped mass is left, the upper surface of which may be above or below low water mark. All trace of æolian stratification has been obliterated by the cementing and solving action of the sea water. If the base, the mushroom-shaped ledge, is stratified horizontally (fig. 2) the result of the wash of the breakers upon any part of the top left unprotected will be to dig out circular or elliptical atolls (fig. 3) like A or B. In one case A the atoll will have a rim of nearly the same width, while in the other case B, if the

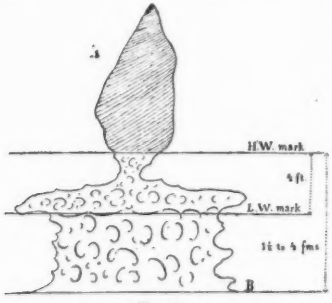
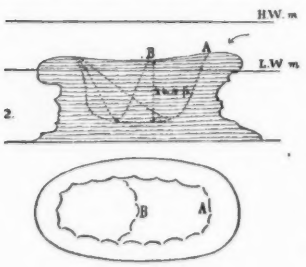


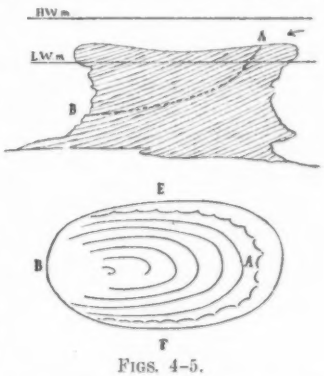
FIG 1.



FIGS. 2–3.

softer parts of the top are on the lee side, the atoll will have a wider rim on the weather side from B to A. The pot holes of these circular atolls are usually from three to four feet in the depth. But in some cases I have measured them between five and six feet and even more. In others they are only a few inches deep. I have not observed any growth of Serpulæ of greater thickness than from 12 to 18 inches.

Should the æolian strata dip towards the lee side (fig. 4) a horseshoe-shaped atoll is formed as indicated by the dotted line AB. The rim is widest at A, fig. 5, gradually becoming narrower towards the lee side as it nears B, the whole or the greater part of the ledge having been carried away by the pounding of the surf, leaving a high narrow wall with a deep opening at B between its extremities. Should the surf break through the sides at E or F or both, we should have curved vertical walls left, apparently built up by Serpulæ, in reality walls of æolian rocks which may be dug out as I have suggested, either in the case of fig. 2 or of fig. 4.



FIGS. 4–5.

In the case of a long and wide ledge we have formed upon it a number of secondary pits and atolls or pot holes as indicated by the heavy lines of fig. 6. Let the walls of these break

FIG. 6.

through and form connecting pot holes of irregular outlines and we obtain a vertical wall such as is indicated by the dotted line of fig. 6. Such a figure is a diagram of one of the ledges of the outer reef off the south shore.

A flat ledge projecting from the base of a shore cliff is eaten into in the same way by the surf (fig. 7) and we have formed a circular reef with vertical walls, of which the top is protected by Algæ and Corallines or Serpulæ with a pot hole at its deepest part of 8 feet. We might call this a diminutive barrier reef.

Before seeing these Serpulæ atolls and reefs I had come to the conclusion that the Hogsty Reef atoll (Bahamas) may have been formed in the same way, by the mechanical action of the surf over a reef which was in great part a veneer on the æolian ledges of its bank, the scour of the mass of water poured into the lagoon gradually hollowing it out. The Hogsty reef is about 4¼ miles long and 2½ miles wide, the depth of the lagoon varies from 2 to 3 fathoms off the platform at the weather extremity to 7 fathoms at the entrance to the lagoon. That water falling can dig out to such a depth is of course well known. On a small scale this can be observed at the foot of every sluice of a draining or irrigating ditch. How deep can it act on a large scale so as to produce an effective result?

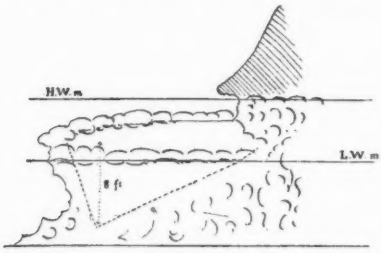


FIG. 7.

ART. L.—*Discovery of Devonian Rocks in California;** by J. S. DILLER and CHARLES SCHUCHERT.

PART I.

DR. J. B. TRASK† was the first to definitely determine by paleontological evidence the geological age of any portion of the auriferous slates of California. He recognized the Carboniferous on the McCloud River. The Geological Survey of California under Prof. Whitney‡ found the Carboniferous in other localities and discovered the Jurassic and Triassic rocks of Mariposa and Plumas Counties. Dr. C. A. White suggested that a part of the Auriferous slates are older than the Carboniferous.§

The present writer, from a study of the structure of the northern end of the Sierra Nevada concluded as follows: "The stratigraphic relations are such as to render it very probable that there is a great thickness of paleozoic strata exposed in the region and that a large part of the gold-bearing slates are

* Published with the permission of the Director of the U. S. Geological Survey. Read before the Geological Society of Washington, D. C., April 25, 1894.

† Report on the Geology of the Coast Mountains, State Senate of California, Document No. 14, Session of 1855, p. 50.

‡ The Auriferous Gravels of the Sierra Nevada of California, p. 34, etc.

§ U. S. Geological Survey Bulletin, No. 15, p. 25. See, also, U. S. G. S. Bull. 19, p. 21, by G. F. Becker.

older than the Carboniferous limestone* and "possibly pre-Carboniferous."†

Since then Silurian rocks have been discovered in that region.‡ Important contributions concerning the identification and distribution of the Carboniferous, Triassic and Jurassic rocks of northern California have recently been made by Becker,§ Turner,§ Lindgren,§ Hyatt,‖ Fairbanks,¶ Mills,** and Smith.††

A great advance in the study of the Auriferous slates of the Pacific coast is made by Mr. Schuchert in discovering Devonian fossils among the collections of the U. S. Geological Survey from northern California. In 1884 the writer found a number of coraliferous limestones three miles southwest of Gazelle in Siskiyou County and on the eastern branches of Soda Creek about five miles N.E. of Lower Soda Springs (Castle Crag) in Shasta Co. Mr. H. W. Fairbanks‡‡ in 1891 discovered a limestone rich in corals about three miles N.W. of Kennet on the divide between Backbone and Little Backbone Creeks in Shasta Co. Before Mr. Fairbanks' results were published he kindly called the writer's attention to this locality. In October, 1893, accompanied by Mr. T. W. Stanton the writer made collections there and since then other exposures of the same coraliferous limestone have been found and collections made on Hazel Creek a few miles east of Southern's.

All fossils collected in 1884 and 1893, at the localities mentioned, were referred to Mr. Schuchert who has definitely determined them to be Devonian as stated in his portion of this communication.

The outcrop of Devonian rocks three miles southwest of Gazelle is one of the best and most accessible for study yet known in California. They are brought to the surface by an eroded arch which exposes the following series in descending order: quartz and other schists; 70 feet of fossiliferous gray limestone succeeded by a few feet of compact limestone and a thick mass of basic eruptives.

West of the axis of the fold this series of Devonian rock dips westward and appears to pass beneath the Scott Mountains. This view is strengthened by the fact that near Parker's on

* U. S. Geological Survey Bulletin, No. 33. p. 18.

† U. S. Geological Survey, 8th Annual Report, p. 407.

‡ Bull. Geol. Soc. of Am., vol. iii, p. 376.

§ U. S. Geol. Survey, Sacramento and Placerville Atlas sheets, also American Geologist. May, 1893, pp. 307–324 and 425 and April, 1894, pp. 248–249.

‖ Bull. Geol. Soc. of Am., vol. iii, pp. 395–412 and vol. v, pp. 395–434

¶ American Geologist, March, 1892, p. 153, February, 1893, p. 69; this Journal, vol. xlv. p. 473, June, 1893; Eleventh Report of the State Mineralogist of Cal., 1893, pp. 24–120.

** Bull. Geol. Soc. of Am., vol. iii, pp. 413–444.

†† Bull. Geol. Soc. of Am., vol. v, pp. 243.

‡‡ Eleventh Report of State Mineralogist of Cal. (1893), p. 48.

the road to Callahan's, about thirteen miles southwest of Gazelle, and also near Oro Fino in Scott Valley, fossiliferous limestone occurs with *Pentacrinus* and appears to be Triassic.

The Devonian limestone four to six miles northeast of Castle Crag, is a veritable coral reef about 60 feet in thickness. It overlies a great mass of dark shales which are apparently older than any of the rocks exposed near Gazelle. This view is sustained by Mr. Schuchert who gives paleontological evidence to show that the fossiliferous rocks of Kennet, Hazel and Soda Creeks belong to a lower horizon in the Devonian than those of Gazelle. The slates, overlying the limestones are much less crystalline than near Gazelle and no eruptives were noticed in the immediate vicinity. These rocks, as well as those near Gazelle, were formerly supposed to be Carboniferous.*

There are two outcrops of Devonian limestone on Hazel Creek about four and five miles respectively east of Southern's. They have a number of fossils in common and probably exposed the same limestone. It overlies a large mass of black slate and dips easterly beneath the Carboniferous, which contains fossils on Tom Dow's Creek. The strike of the Carboniferous at that point is east of north, dipping towards the southeast and probably connects with the well known locality of Grizzly Peak about fourteen miles further to the northeast.

According to Mr. Storrs, who collected the fossils on Hazel Creek, the dip of the limestone is easterly and overlies a great mass of black slate. Its strike is a little east of north, connecting it directly with that of the same horizon on Soda Creek as well as that near Kennet further southward.

Three miles west of Kennet, a mile beyond Mr. Matson's lime kiln at a locality discovered by Mr. Fairbanks,† the limestone in places is composed almost wholly of branching corals and is in reality a coral reef about 50 feet in thickness. It is much warped but generally dips to the eastward beneath the Carboniferous which occurs along the McCloud River.

The region directly westward of the great bend of Pitt River has yielded many fossils belonging to the Jurassic, Triassic, Carboniferous and Devonian systems. All of which are arranged in successive belts increasing in age westward in the Klamath Mountains, indicating the presence of rocks of still greater age about the central portion of that mass. The general strike of the Devonian rocks from near Kennet is about north 18° east, which is in line with the outcrop of Hazel Creek and Soda Creek, over thirty miles away. If they are really continuous for this distance as appears probable it suggests as previously urged by the writer that the axis of folding joins the Klamath Mountains to the Coast Range rather than to the Sierra Nevada.

J. S. D.

* U. S. Geological Survey, Bull. 33, p. 11.

† Eleventh report of the State Mineralogist of Calif., p. 48.

Part II.

During the field seasons of 1884 and 1893, the U. S. Geological Survey acquired six lots of Devonian fossils, collected by Messrs. Diller, Stanton, and Storrs, from six localities in Shasta and Siskiyou counties, California.

These fossils, comprising about thirty species, most of which are corals, demonstrate the undoubted presence of middle Devonian deposits in California where rocks of this age have long been looked for by geologists, more particularly since the recent discovery of Silurian fossils.* In the geological literature treating of California, the writer finds that Mr. Fairbanks was probably the first to refer certain strata provisionally to the Devonian. He says: "In my former paper I traced the Paleozoic rocks of Shasta county, part Carboniferous and part probably Devonian, south along the main Coast range to San Francisco Bay."† This is the only specific reference to probable Devonian rocks in California. The locality on which Mr. Fairbanks based his conclusions is near Kennet on the Sacramento River, and is described by him as follows: "The fossils in the limestone [of Backbone Creek] are exclusively corals, and in places the branching stems [*Cladopora*] form almost the complete mass and weather out finely on the surface. In fact the great mass of the limestone seems to be made of corals."‡

The most southerly of these localities (No. 1 of the annexed table) is three miles northwest of Kennet. The next two (Nos. 4 and 5) are about twenty-two miles north on Hazel Creek, and two others (Nos. 2 and 3), ten miles above the latter on one of the branches of Soda Creek, about five miles northwest of Castle Crag. This fauna indicates a single terrane, since the localities each have from one to four species in common, as the annexed list of fossils shows.

About thirty miles to the northwest of the Hazel Creek localities, at a place three miles southwest of Gazelle, Siskiyou county (locality 6), there is another outcrop of Devonian limestone yielding a larger fauna of corals and some Mollusca. Fossils were collected from this limestone, both in 1884 and in 1893. This horizon appears to be higher or younger faunally than that just mentioned, since but one of its species is known to occur in the Devonian limestone of Shasta county. All of the fossils studied are from limestone, and nothing as yet is known of a sandstone or shale fauna.

* Geol. of the Taylorville region of Cal., by J. S. Diller. Bull. Geol. Soc. America, vol. iii, p. 376, 1892.

† American Geologist, vol. xi, p. 70, 1893.

‡ Eleventh Rep. State Mineralogist of Cal., p. 48, 1893.

Notes on the fossils.

Favosites canadensis, *Cladopora labiosa*, *C. acupicta*, and *Syringopora maclurii*, are characteristic forms of the great coral reef of the Corniferous limestone, as developed in eastern North America. The material from the Shasta county localities agrees closely with the descriptions of these species, and the identifications, therefore, are regarded as fairly accurate. Associated with these fossils are a number of other corals, which could not be identified specifically, however, since some are new and of others the material is not well preserved. These corals are given in the first five columns of the annexed list.

The *Alveolites* provisionally referred to *A. minimus* Davis, is represented in Nevada by *A. multilamella* Meek.* The corallites in the California specimens are quite tortuous, and have thinner walls, thus differing distinctly from Meek's species. Externally the present specimens agree with the figures of *A. minimus*, but, no positive identification can be made as Davis† gives no description of any of his species and usually no figures of their internal structure.

Acervularia pentagona Goldfuss, sp., as identified by Meek,‡ occurs at "Treasure Hill, Nevada, in silver bearing Devonian Beds." The California specimens are found in masses six inches in diameter, and appear to have a somewhat larger number of septa than the Nevada form. These differences, however, are not sufficient for specific separation. All the other known species of American *Acervularia* have larger corallites than *A. pentagona*.

The California examples of *Diphyphyllum fasciculum* Meek,§ agree fairly with the Nevada specimens from "Argyle and Treasure Hills, White Pine Mining District." A closely related form, with fewer and not so closely approximating corallites, also occurs at localities 2 and 3. Meek has united these in his *D. fasciculum*.

The *Endophyllum* occurring near Gazelle is interesting since it is the first known occurrence of this genus in America. It differs chiefly from *E. bowerbanki* and *E. abditum* Edwards and Haime,‖ of the Devonian of Devonshire, in having much smaller corallites.

A form of *Gypidula* from the same locality may prove to be the same as *Pentamerus comis* or *P. lotis* Walcott,¶ occur-

* Op. cit., p. 25, Pl. II, figs. 7–7b.
† Kentucky Fossil Corals; Kentucky Geol. Survey Reports, 1885.
‡ Geol. Expl. 40th Paral., vol. iv, 1877, p. 31. Pl. II, figs. 5, 5a.
§ Op. cit., p. 29, Pl. II, figs. 4–4b.
‖ Mono. British Fossil Corals, Pt. IV, p. 233, 1853.
¶ Mono. viii, U. S. Geol. Survey. pp. 159–161, 1884.

ring respectively in the Eureka and White Pine Mining Districts of Nevada. The California specimens consist of separated and distorted valves.

Correlation with other regions.

The corals of the Devonian limestone of Shasta county are believed to indicate the lower portion of the middle Devonian or approximately the Corniferous terrane as developed in New York, Kentucky, Michigan, and Ontario. It should be borne in mind, however, that since many species of corals have a great geographical and considerable vertical distribution, great reliance cannot always be placed on them for limited correlation. Mr. Walcott* has identified twenty-five species of this class in the Devonian of Nevada. Some of them hold a different stratigraphic position from the same species in eastern America. He writes: "Among the corals, *Cladopora pulchra*, *Syringopora hisingeri*, and *Cyathophyllum corniculum*, of the great Corniferous coral reef of the east, occur at the upper horizon, and *Syringopora perelegans*, of the same formation in New York, ranges throughout the group in Nevada."†

The fossils from near Gazelle, in Siskiyou county, here considered as of later or younger age than those of the Shasta county limestone agree, in a few cases specifically with the Devonian fauna of the White Pine Mining District in Nevada. Two species, *Acervularia pentagona* and *Diphyphyllum fasciculum*, certainly occur in both regions, while *Pentamerus comis* or *P. lotis* also seems to be present. A single small *Bellerophon* was found with these species, and may prove to be a young specimen of *B. perplexa* Walcott, as found in the Eureka District of Nevada. The Devonian strata of the White Pine Mining District are silver-bearing, while the middle Devonian horizons of Shasta and Siskiyou counties are a part of the Auriferous series of California.

List of species known to occur in the Devonian of California.

	Shasta County.					
	1	2	3	4	5	6
Favosites clelandi Davis?	×					
" *canadensis* Billings	×	--	--	×		
" species No. 1	--	--	--	--	--	×
" " No. 2	--	--	--	--	--	×
" " No. 3	--	--	--	--	--	×
" " No. 4	--	--	--	--	--	×
Cyathophyllum robustum Hall, 1876?	--	--	--	×		
" branching form No. 1	--	?	×			
" " " No. 2	×	--	--	?	×	

* Mono. viii, U. S. Geol. Survey, pp. 100–106, 1884.

† Op. cit., p. 4.

List of species known to occur in the Devonian of California.

	Shasta County.					
	1	2	3	4	5	6
Diphyphyllum, sp. undet., or *Syringopora*	--	×				
" *fasciculum* Meek	--	?	?	--	--	×
Acervularia pentagona (Goldfuss) Meek	--	--	--	--	--	×
" sp. undet	--	--	--	--	--	×
Endophyllum, n. sp.	--	--	--	--	--	×
Cladopora acupicta Davis	×					
" *labiosa* Billings	×	--	--	×		
Alveolites cfr. *minimus* Davis?	×	--	×	--	×	
Syringopora Maclurii Billings	--	--	--	×		
Monticulipora, species No. 1	×	--	--	×		
" " No. 2	--	×				
Leptotrypa	--	--	×			
Gypidula cfr. *comis* Owen, and *G. lotis* Walcott	--	--	--	--	--	×
Conchidium? A small strongly plicated form	--	--	--	--	--	×
Terebratuloid cfr. *Newberria*	--	--	--	--	--	×
Loxonema cfr. *delphicola* Hall	--	--	--	--	--	×
" or *Murchisonia*	×					
Murchisonia	--	--	--	--	--	×
Bellerophon, much like the Russian *B. septentrionalis* Tschernyschew, but may be a young specimen of *B. perplexa* Walcott	--	--	--	--	--	×
Mytilarca sp. undet.	--	--	--	--	--	×
Orthoceras	--	--	--	--	--	×
Large crinoid columns	×	--	--	--	×	×
	9	4	4	6	3	17

C. S.

U. S. Geol. Survey, Washington, D. C., March 14, 1894.

Art. LI.—*On the Blue Iodide of Starch;* by Charlotte F. Roberts.

[Contributions from the Kent Chemical Laboratory of Yale College—XXX.]

The interesting article by Mylius* on the composition of blue iodide of starch, and the reply to the same by Stocks,† have suggested to me a few simple experiments, the record of which will perhaps be interesting to others who, like myself, may have been puzzled to decide between the adverse views, especially since the papers above referred to are somewhat lacking, in certain portions, in experimental evidence of the facts stated.

Mylius derives as the formula for the blue iodide of starch $(C_6H_{10}O_5I)_nHI$, in which n probably equals 4, and states that it

*Ber. d. d. chem. Gesell., xx, 688. †Chem. News, lvi, 212.

is formed by the union of the colorless, or yellow, compound $C_6H_{10}O_5I$ with hydriodic acid or one of its salts. He affirms that a pure solution of iodine and starch gives no blue color, but that the liquid must contain an iodide, a trace of which is sufficient to bring about the desired result.

My own study of the blue iodide of starch may be considered under two heads:

1st. Its Decompositions.

2d. The Conditions of its Formation.

1. *Decomposition of Starch Blue.*

(*a*) By heat. The effect of heat on the blue iodide of starch is well known. If moderately heated, the blue color returns on cooling, but if strongly heated in an open vessel, it remains permanently colorless. The explanations of this change, however, have been varied, some authorities stating that all of the iodine is driven off by the stronger heat, others that it is converted into iodic acid, and still others that the product of the reaction is hydriodic acid. Stocks affirms the last, and a very simple experiment seems to support this view. If to the cooled, colorless liquid, a few drops of iodic acid be added, the clear blue color is immediately restored. This experiment was performed in a platinum vessel, and the same results were obtained whether iodic acid were used alone or mixed with dilute sulphuric acid, though the latter acid by itself has no effect in restoring the color. That unaltered starch remains in this solution after heating, is proved by the fact that a drop of iodine colors the cold solution blue.

While the fact that hydriodic acid is split off from the iodide of starch under the influence of heat cannot be used as an argument either for or against Mylius's views, these phenomena are perhaps what might be expected if his views be correct. The first effect of heat seems to be to produce a kind of dissociation, the hydriodic acid splitting off from the rest of the molecule and going back into it when cooled, but upon longer heating the iodine which is directly united with the starch molecule is either driven from the liquid or converted into hydriodic acid. Upon the addition of iodic acid, some iodine is set free which, along with the hydriodic acid, unites with the starch to form the blue color. These phenomena are thus shown to be in harmony with Mylius's theory, although no proof of its correctness.

(*b*) By iodic acid. If some blue iodide of starch be precipitated and well washed with dilute sulphuric acid, and then iodic acid added, the solid dissolves to an apparently colorless liquid. That this solution, however, contains free iodine, may be proved by adding chloroform, which becomes tinged a decided pink. This would indicate that the iodic acid acted by

withdrawing hydriodic acid from the molecule, thus setting free iodine.

(*c*) By a solution of a silver salt. One of the strongest proofs which Mylius gives for the correctness of his views is that the blue color is destroyed by a silver salt, that the addition of pure iodine now does not restore the color, only turning it yellow, but that the addition of hydriodic acid or potassium iodide gives the blue at once.

I have found, in fact, that a single drop of a very dilute solution of silver nitrate is sufficient to destroy the deep blue color in a test-tube full of liquid. A natural explanation, in the light of the preceding experiments, is that the silver nitrate withdraws hydriodic acid; and the ease and completeness of the change supports the view that this exists as such in the molecule, since in many organic compounds, the halogen is extracted only with difficulty if at all by silver nitrate. This view is still further supported by the fact that the blue color is immediately restored by the addition of a little hydriodic acid. The color is also restored, though not to its former depth, by the addition of a few drops of strong hydrochloric acid, or by a larger quantity of the dilute acid, though it is not affected by sulphuric acid. This can readily be explained on the supposition that the silver iodide is partially decomposed by the hydrochloric acid, giving sufficient hydriodic acid to form some of the blue iodide. That this is the correct explanation rather than that hydrochloric acid can be substituted for hydriodic in the starch compound without changing its color is proved by filtering after adding silver nitrate, and adding hydrochloric acid to the filtrate, when no blue color is produced.

If we concede that in all three of these cases, the decomposition has been effected by a withdrawal of hydriodic acid, it certainly shows a tendency for that portion of the molecule to split off, which is suggestive of its existing already formed as such in the molecule, and in so far is in harmony with Mylius's views, though the mere fact that hydriodic acid is withdrawn is no proof that it goes into the molecule as such. The only portion of the above which can be considered at all as direct proof of Mylius's statement is that after the blue color has been destroyed by silver nitrate, it can be reformed by the addition of hydriodic acid. This would seem certainly a strong argument in support of Mylius.

We pass next to the consideration of

2. *The Conditions of Formation of Blue Iodide of Starch.*

Mylius makes three statements in regard to this which may be quoted here.

(1) An aqueous solution of iodine cannot color starch blue, but the color appears immediately if a trace of hydriodic acid or potassium iodide be added.

(2) Iodine solutions which color starch blue contain hydriodic acid or one of its salts.

(3) The presence of substances which destroy hydriodic acid, as, for example, chlorine and iodic acid, prevents the formation of starch blue.

These different statements will be considered in the order in which they are here quoted, but (1) and (2) are so nearly identical that they cannot be kept separate.

I have never succeeded in obtaining aqueous solutions of iodine and starch which, upon being mixed, did not produce a blue color, although great care was taken to avoid the possibility of any alkali from glass getting into the solutions. According to Mylius, this is the great cause of the presence of iodide in an iodine solution. In my experiments, the iodine was powdered, left standing for some time in a mixture of iodic and sulphuric acids, then washed thoroughly with water, and finally dissolved in water, all of these processes being carried on in a platinum dish. An emulsion of arrow-root, also well washed, was made in a platinum dish, and the two solutions were mixed in a platinum crucible. Notwithstanding all of these precautions, the blue color appeared immediately. This would seem to indicate that Mylius's views were erroneous, but on the other hand, I was able to prove the presence of hydriodic acid in my aqueous solution, even thus carefully prepared. I did this by shaking the solution with chloroform and separating the two liquids with a separating funnel, and repeated this until the chloroform added remained perfectly colorless. Then, upon the addition of a few drops of iodic acid, and shaking, the chloroform became faintly but undoubtedly tinged with pink. It is proved, then, that this liquid which colored starch contained hydriodic acid, but it still remains an open question whether this iodide was an impurity in the iodine, not removed by its repeated washings, which seems hardly probable, or whether it is formed whenever iodine dissolves in water, and is therefore, in traces, a necessary accompaniment of every iodine solution.

That glass has a more powerful action on an iodine solution than has generally been supposed cannot however be doubted. My own attention has been drawn to this fact by the difference in behavior of the liquid which results when starch blue is heated in a glass tube and that which is formed when the same compound is heated in a platinum vessel. In the first case the cold, colorless solution is turned blue by the addition of any acid, whereas in the latter case, iodic acid is the only one

which has this power. In case sulphuric acid is added to the liquid before heating in the test-tube, the color is not restored by any acid, even iodic.

Although I have found it impossible to mix carefully prepared solutions of iodine and starch without getting a blue color, if only a drop or two of iodine be added to an excess of starch, the blue formed where the liquids first touch, disappears in the mass of the liquid, and then the addition of hydriodic acid brings out the blue color distinctly. This is in harmony with Mylius's statements, and also with the fact that in working with dilute solutions in a large bulk of alkaline liquid, the delicacy of the starch test for iodine is increased by the addition of two or three grams of potassium iodide.

In a further effort to prepare iodine free from iodides, I have taken an iodine solution, shaken it with chloroform, rinsed with water, and finally drawn off the chloroform solution. Then, upon adding pure water and shaking some of the mixture with starch, the starch remains uncolored. If, however, this mixture of iodine in chloroform and pure water be heated and then cooled, or if it be exposed to the sunlight in a platinum dish for about an hour, the mixture acquires the power of coloring starch immediately, and the colorless aqueous portion of yielding iodine to chloroform when treated with iodic acid. The appearance of free iodine, indicated by the chloroform, showed that hydriodic acid had been formed by the iodine and water on heating or in sunlight.

It has just been shown that if a solution of iodine in chloroform be washed with water, separated from the aqueous portion, and starch added, there is no immediate change of color; but the blue color may be brought out in three different ways:

(1) By addition of a drop of dilute hydriodic acid.

(2) By heating and then cooling the liquid.

(3) By long standing.

The evidence of (1) is a direct support of Mylius's views, and (2) and (3) may be considered as indirectly indicative of the same, since they give conditions under which hydriodic acid might presumably be developed. Further evidence in the same direction may be found in the following experiment. An emulsion of starch in chloroform was made, and to this a solution of iodine in chloroform added. The color remained unaltered, but the addition of a little potassium iodide, either in the solid form or in aqueous solution, immediately produced the blue color. The addition of pure water failed to give the blue color until after standing for several hours.

There seems, then, to be sufficient evidence that all solutions which form starch blue contain an iodide, and also, considering the experiments with chloroform, that solutions freed

from hydriodic acid cannot produce that color, although in my experiments I have not been able to make an *aqueous* solution of iodine which did not turn starch blue, and which did not contain hydriodic acid.

We pass now to the third argument of Mylius quoted above, viz: the deterrent action of chlorine and iodic acid on the formation of starch blue.

In regard to the action of chlorine, Stocks quotes the suggestion of Miller that it may be due to the formation of iodine chloride, which is well known to have a destructive effect on the blue iodide of starch. But even granting this as an explanation, two questions remain to be answered; first, how is the iodine chloride formed, and second, what is its action on starch blue? It can hardly be supposed that the chlorine withdraws the iodine bodily from the organic molecule. A much more natural assumption would be that the chlorine decomposes hydriodic acid, setting free iodine; and here we have sufficient cause for the destruction of the blue color. But granting that the reaction may go farther, and the iodine thus set free unite with an excess of chlorine to form iodine chloride, is not this also a body which might be expected to act by destroying hydriodic acid? I have found, in fact, that when iodine chloride is added to starch blue, iodine is set free, the result which might be expected if the iodine chloride acts upon the hydriodic acid in the compound according to the reaction:

$$HI + ICl = HCl + I_2$$

This experiment was performed as follows: Iodine chloride was prepared by putting together potassium iodide and hydrochloric acid in an excess of iodic acid. It was then separated from the other bodies by extraction with ether, and to the ethereal solution, starch blue was added. The color was taken from the starch, and the ether became darker and brown. To prove that this change in the ether was really due to free iodine, it was left standing over pure water for some time, with occasional shaking. Finally, some of this aqueous portion was shaken with chloroform, to which it gave the characteristic pinkish tinge. As iodine chloride gives no color to chloroform, this shows conclusively that iodine had been set free.

There remains to be considered only the action of iodic acid on the iodide of starch. Its action on the precipitated blue after formation has already been referred to, so that at this point, we need only consider its action in preventing the formation of starch blue.

It is an undeniable fact that when dilute solutions of iodine are used, iodic acid in sufficiently large quantities prevents the formation of starch blue both when used alone, and when used

with other acids, but a much smaller amount of iodic acid is necessary if mixed with another acid, as for example, sulphuric acid. This may be explained either on the assumption of a more rapid action when sulphuric acid is used, as Landolt* has found to be the case in the reaction between iodic acid and sulphurous oxide, or in the case of ordinary iodine solutions prepared and kept in glass vessels, it may be supposed due to the fact that the liquid contains iodides and iodates derived from the glass. I have tried bringing together extremely dilute solutions of iodic acid and of potassium iodide, and found that no perceptible amount of iodine is set free, though in more concentrated solutions, the iodine is set free in nearly the quantitative yield represented by the equation:

$$5KI + 6HIO_3 = 5KIO_3 + 3H_2O + 3I_2$$

In this reaction, however, the amount of iodine found is always a trifle too low, probably due to the fact above shown, viz: that in very dilute solutions, the iodide and iodic acid do not react on each other, except in presence of another acid. The dilute sulphuric acid alone when added to starch blue does not bleach the color, but diminishes the intensity to an appreciable degree.

The amount of iodic acid necessary to prevent the formation of the blue color depends not only on the amount of other acid present but also on the order in which the reagents are put together. Thus I have found in several cases that, with a definite amount of iodic acid and iodine, there was no color produced if the iodine, iodic acid, and sulphuric acid were mixed first, and left standing for some minutes or half an hour before adding the starch; whereas, if the starch were put in first and the other three constituents added directly, a blue color would result which could only be destroyed on long standing and shaking, if at all.

In general, the amount of iodic acid necessary to prevent the formation of the starch blue seems in very great excess of that which would be necessary to destroy all of the hydriodic acid which can possibly be present. It is only by following the precautions suggested above that the iodic acid needed can be made to bear any reasonable relation to this hydriodic acid. I have dissolved iodine in a mixture of iodic and sulphuric acids, and added starch and obtained immediately a blue color, though naturally not as deep and intense as would be obtained without the iodic acid. This solution was as strong as possible of iodine, being made up with powdered iodine in a platinum dish, and containing always some of the undissolved solid. The liquid poured off from this, whether filtered or not, and

* Ber. d. d. chem. Gesell., xx, 745.

even when it had considerable iodic acid added to it, refused under any circumstances to give a colorless liquid with starch; and the same was found true even when it was left standing with additional iodic acid for half an hour before the starch was added.

These facts and the fact that the purest possible, freshly prepared aqueous solution of iodine may be shown to contain hydriodic acid, have suggested to me the possibility that hydriodic acid may be constantly forming in traces when iodine dissolves in water, and that, therefore, no aqueous solution can be free from it whether kept in glass or not, though there is no doubt that the glass may greatly increase the amount. So many facts seem to point to the truth that hydriodic acid or one of its salts is taken up as such into the molecule of the blue iodide of starch that the fact of the large amount of iodic acid necessary to prevent its formation can hardly be considered a sufficient argument against that belief, though we naturally question what may be the reason for this necessary excess. There seem to me to be two possible explanations, either the iodic acid destroys hydriodic acid much less readily in dilute solutions than has been generally supposed, or some hydriodic acid is constantly being formed in an iodine solution, and perhaps the correct explanation lies in the union of these two.

Landolt* has made some investigation of the reaction between iodic acid and hydriodic acid in dilute solutions, and has found that in an extremely dilute solution, nineteen seconds may elapse before the formation of iodine makes itself manifest by the blue color given to starch. I have used even diluter solutions than he, and found that with ·000009 grams iodic acid and ·000033 grams potassium iodide in 20 cubic centimeters of water, no color appeared with starch until several minutes had elapsed if only a small quantity of sulphuric acid was present, whereas if one-fourth of the liquid consisted of dilute sulphuric acid, a blue tinge appeared immediately. The completeness of the reaction in a given time, then, is seen to depend on the amount of sulphuric acid present, and there is nothing to show whether it is finally complete or whether there may be left traces of undecomposed hydriodic acid.

If we assume that hydriodic acid is constantly being formed in traces in an iodine solution, and remember that the reaction between hydriodic acid and iodic acid is not an immediate one in the presence of a large quantity of water, we can understand why a considerable excess of iodic acid must be used in order to destroy completely the last traces of hydriodic acid and thus entirely prevent the formation of starch blue.

* Ber. d. d. chem. Gesell., xix, 1317.

Art. LII. — *Beaver Creek Meteorite;* by Edwin E. Howell.

In the number of "Science" dated July 21st, 1893, I gave a brief history of this meteorite as then known, and proposed the above name from the stream near which it fell.

The accompanying cut gives a fair idea of the stone as first seen by me. It measured $6\times7\times9\frac{1}{2}$ inches and weighed $22\frac{1}{2}$ pounds. About 3 or 4 pounds had been broken from the bottom as shown in the cut. The original weight must have been approximately 26 pounds and the length 12 inches.

After repeated efforts and much correspondence I have been unable to secure any more of the fall. The reports at first stated that two smaller pieces of a few pounds each were seen to fall. This however seems to have been a mistake, as only one other piece of 4 or 5 pounds so far as I can learn was seen. A portion at least of this smaller piece was broken into fragments and distributed the same as the most of that which was broken from the larger mass before it came into my possession, July 6th, 1893, by purchase from Mr. James Hislop, a Civil Engineer, who found and dug it up the morning after it fell and brought it to Washington. It buried itself in the earth about 3 feet—2 feet in soil and 1 foot in hard pan.

The direction of the hole was south 60° east, true meridian, and at an angle of 58° with the horizon. Fresh earth was scattered about the hole in all directions, but farthest (10 feet) in the direction from which the stone came.

It fell between the hours of 3 and 4 P. M. May 26th, 1893, near Beaver Creek, West Kootenai District, British Columbia, a few miles north of the U. S. Boundary and about ten miles above where the creek joins the Columbia River.

The report was heard by persons within a radius of nearly twenty-five miles, and it was believed by many who heard it that larger pieces must have fallen than those secured. The stone is a typical aerolite of very pronounced chondritic structure, has the usual fused black crust, but has one feature unlike any other meteorite with which I am familiar. Beneath the crust there is a slight oxidation for a distance of from one-half to three-quarters of an inch which seemingly must have

occurred before it struck the earth, and for which thus far no satisfactory explanation is suggested.

There is no occasion to further describe the character of this stone as that part will be found fully discussed in the accompanying papers by Drs. Hillebrand of the U. S. Geological Survey and Merrill of the U. S. National Museum.

Chemical Discussion; by Dr. W. F. Hillebrand.

The material received for chemical examination was in a crushed state, much of it in fine powder, being the waste resulting from cutting the rocky mass. There was scattered throughout it some organic matter derived from a burnishing brush, which, though insignificant as regards weight, rendered useless any attempt to look for organic matter proper to the meteorite itself.

Of this mass, 26·1892 grams, after repeated separation under alcohol by an electro-magnet, yielded 5·0710 grams of magnetic material which still contained over 10 per cent of unmagnetic substance, as shown by the following analysis:

Analysis of magnetic material.

Fe	80·21	88·456
Ni	7·78	
Co	·44	
Cu	·026	
Silicates*	5·17	
SiO_2†	1·31	
MgO	1·31	
FeO‡	1·20	
Fe_3O_4	·83	
FeS§	·77	
P_2O_5¶	·057	
Al_2O_3, CaO, Alk. and loss, by diff.	·897	
	100·000	

The metallic part therefore comprises 17·13 per cent of the meteorite and is composed as follows:

* Insoluble in dilute HCl.

† Total silica from decomposed silicates.

‡ Calculated from the composition of soluble silicates, as given in a subsequent analysis.

§ Found by treatment of the magnetic part with dilute HNO_3, followed by separation by an electro-magnet from unattacked silicates. Hydrochloric acid was then used to free it from a small residue of insoluble silicates, and from this solution the iron was precipitated by ammonia and weighed, whence the weight of Fe_3O_4 was calculated.

‖ By estimation of sulphur (·28 per cent).

¶ A portion of the phosphorus may very possibly be derived from schreibersite.

Fe	90·68
Ni	8·80
Co	·49
Cu	·03
	100·00

By the procedure outlined in one of the footnotes to the foregoing analysis the isolation of magnetite from all but a very small proportion of siliceous matter is easy. It then appears under the microscope as irregular grains of a dull black lusterless surface. Only one grain presented an apparently octahedral aspect.

The main portion of the meteoric material, now freed from all magnetic matter, was thoroughly mixed and pulverized. Its composition follows:

Analysis of unmagnetic material.

S	2·21	6·08 troilite.
Fe	3·87	
FeO	·24	·75 chromite.
Cr_2O_3	·51	
SiO_2	45·87	
TiO_2	·09	
Al_2O_3	2·30	
FeO	12·44	
NiO	·07	
MnO	·26	(too low).
CaO	1·96	
MgO	28·24	
K_2O	·15	
Na_2O	·98	
Li_2O	none	
H_2O above 100° C.	·34	
P_2O_5	·30	
Cl	trace	
	99·83	

The assumption of FeO as the sole divalent element in the chromite is entirely arbitrary. Qualitative tests on a minute quantity separated from the silicates showed that the mineral carried magnesia and alumina also. The extremely weak magnetism of the troilite appears clearly from the fact that the electro-magnet produced only a barely perceptible concentration of it in the magnetic mixture, as shown by comparing the percentages of troilite and of silicates therein with those just above.

A portion of the unmagnetic powder was then divided into a soluble and an insoluble part by digesting for a few hours

with dilute hydrochloric acid on the water bath, filtering, separating gelatinized silica by dilute solution of potassium hydroxide, and repeating the treatment of the residue with acid and alkali. In this way there was decomposed 51·11 per cent of the whole. The composition of both soluble and insoluble parts as actually found by analysis is as follows, the S and P_2O_5 being taken from the previous analysis, as also the water of the soluble part after allowing for the trifle belonging to the insoluble portion.

Soluble portion, 51·11 per cent.			Insoluble portion, 48·89 per cent.	
S	2·21	6·08 troilite.		
Fe	3·87			
FeO	·01	·04 chromite	·23	·73 chromite.
Cr_2O_3	·03		·50	
SiO_2	17·03		27·74	
TiO_2	----		·09	
Al_2O_3	·25		2·34	
FeO	8·69		3·85	
NiO	·04		trace	
MnO	·12		·17	
CaO	·46		1·65	
MgO	17·24		11·14	
K_2O	·01		·12	
Na_2O	·06		·90	
H_2O above 100° C.	·31		·03	
P_2O_5	·30		--	
Cl	trace		--	
Loss	·48		·13	
	51·11		48·89	

Excluding troilite and chromite, but including phosphate, the percentage composition of the soluble and insoluble mixtures is as follows:

	Soluble portion.	Insoluble portion.
SiO_2	38·26	57·75
TiO_2	----	·18
Al_2O_3	·56	4·89
FeO	19·52	8·02
NiO	·09	trace
MnO	·27	·35
CaO	1·03	3·44
MgO	38·73	23·19
K_2O	·02	·25
Na_2O	·13	1·87
H_2O above 100° C.	·70	·06
P_2O_5	·68	----
Cl	trace	----
	99·99	100·00

Whether the titanium belongs to the pyroxene or is to be credited to a special titaniferous mineral, such as ilmenite for instance, the analysis does not show. The siliceous constituents of the stony matter appear from the analysis to be chiefly olivine and the bronzite variety of enstatite. In order to throw further light, if possible, on the character of the mineral or minerals in the insoluble part, a portion of the latter was subjected to prolonged treatment with hydrochloric acid followed by dilute potassium hydroxide solution, after which an attempt was made to effect further separation by the Sonnstadt solution with very limited success. The main portion thus finally obtained was analyzed. It gave the following composition:

FeO	·31	·96 chromite.
Cr_2O_3	·65	
SiO_2	56·48	
TiO_2	·19	
Al_2O_3	2·65	
FeO	9·14	
NiO	?	
MnO	·46	
CaO	2·97	
MgO	25·86	
K_2O	·18	
Na_2O	1·20	
H_2O	?	
	100·09	

Comparison of this with the preceding analysis of the insoluble part of the meteorite shows unquestionably that its siliceous component is a mixture and that the effect of the second acid and subsequent mechanical treatment was to remove partially a relatively soluble alkali-lime-alumina silicate. That this more soluble ingredient is largely of feldspathic nature is, however, negatived by the fact that the last analysis, omitting chromite and titanium, affords almost exactly a metasilicate ratio, and by the failure of Dr. Merrill to identify any feldspathic mineral constituent in more than mere traces.

From the data at hand the composition of the meteorite as a whole resolves itself as follows, assuming for the mixed silicates in the magnetic portion the same composition as that shown by the non-magnetic mixture:

Nickel-iron	17·13	
Magnetite	·16	
Troilite	5·05	(·15 in magnetic, 4·90 in non-magnetic part)
Soluble silicates and phosphate	37·23	
Insoluble silicates and chromite	40·43	
	100·00	

Microscopical Discussion; by DR. GEO. P. MERRILL.

The stone is of a gray color and granular structure, quite fine grained and friable but showing to the unaided eye a finely granular groundmass studded with small spherules or chondri in sizes rarely if ever exceeding 2^{mm} in greatest diameter, and averaging not more than half that amount. With the pocket lens it is seen that the groundmass is also largely chondritic, but interspersed with granular material and glistening metallic particles. So far as material is at hand for comparison, the stone macroscopically most resembles that of New Concord, Ohio, but is much more granular and friable, as well as more pronouncedly chondritic. In the thin section under the microscope it presents no features not common to stones of its class, and various portions of the field show structures in every way similar to those of the meteorites of Mezo-Madras, Homestead, and Dhurmsala as figured by Tschermak* or that of the San Emigdio stone as described by myself.† There are the usual monosomatic and polysomatic chondri sometimes of olivine alone, enstatite alone, or olivine and enstatite together, in granular or porphyritic forms with glassy base, or radiating and barred forms. The olivines not infrequently occur with interiors made up of small rounded granules imbedded in a glass base, but extinguishing simultaneous with the outer portion. In many respects the microstructure closely simulates that of the San Emigdio stone, but the apparent fragmental nature is less conspicuously marked. In two instances small irregular colorless granules were observed giving faintly the twinning striæ and inclined extinctions characteristic of plagioclase feldspars. It is not possible from the examination of the two slides at command to state more definitely as to the presence or absence of this or of silicate minerals other than those mentioned.

* Die Mikroskopische Beschaffenheit der Meteoriten, etc. Plates VII and VIII.
† Proc. U. S. National Museum.

Art. LIII.—*On Allanite Crystals from Franklin Furnace, N. J.;** by A. S. Eakle.

Allanite, as a rock constituent, has been shown to be very widespread in its occurrence and the crystallographic properties of the mineral from many localities, have been determined. The present article is the result of an examination of a large number of crystals coming from the Trotter Mine, Franklin Furnace, N. J.

The presence of allanite at Franklin Furnace was first reported in 1850, by C. T. Jackson,† who published a short description of its occurrence and an analysis. His crystals came from a different locality, being in the feldspar of the old magnetite mines, while those described here occur with the zinc ores, in a great granite dyke.‡

The crystals are coal-black in color, very brittle, and occur in the common, flat, tubular forms, elongated parallel to the ortho-axis. The faces of the crystals are, in general, dull, and when magnified appear to be much pitted, so that reflections with the Fuess goniometer are poor. Imperfect cleavage occurs parallel to the basal- and ortho-pinacoid faces and more perfect in the direction of the prism face, but varying about 6° 30′ from parallelism. An average of several readings gives an angle of 47° 56′ between this cleavage face and the ortho-pinacoid.

Fourteen forms, in all, occur on the crystals, none of them, however, being new. The forms are the following:

$a = \infty P\bar{\infty}$	(100)	$n = P$	$(\bar{1}11)$
$c = 0P$	(001)	$o = P\dot{\infty}$	(011)
$d = -P$	(111)	$r = P\bar{\infty}$	$(\bar{1}01)$
$e = -P\bar{\infty}$	(101)	$u = \infty P\bar{2}$	(210)
$i = \frac{1}{2}P\bar{\infty}$	$(\bar{1}02)$	$w = -2P\bar{2}$	(211)
$l = 2P\bar{\infty}$	$(\bar{2}01)$	$s = \frac{1}{3}P\bar{\infty}$	$(\bar{1}03)$
$m = \infty P$	(110)	$x = -\frac{1}{2}P\bar{\infty}$	(102)

The forms x, i and o are less common, and w and s are rare. The remaining faces are quite common to the species, not alone in this locality, but in general. On the "bucklandite" (allanite) of the Laacher See,§ and later on the allanite from Vesuvius,‖ Dr. G. vom Rath has described a large series of forms, most

* Published in the Trans. N. Y. Acad. Sci., Nov. 27, 1893.

† Allanite from Franklin Furnace, N. J., C. T. Jackson. Proc. A. A. A. S., 1850, p. 323.

‡ Kemp, J. F., Trans. N. Y. Acad. Sci., Oct. 30, 1893.

§ G. vom Rath, Ueber die Krystallform des Bucklandits vom Laacher See, Pogg. Ann. Phys. und Ch., vol. cxiii, p. 281.

‖ G. vom. Rath, ibid., vol. cxxxviii, p. 492.

of them being common on the Franklin crystals. Later, W. C. Brogger* has determined about the same faces on the allanite crystals of southern Norway.

In the drawings accompanying this paper are shown the various combinations. They are all drawn from the individual crystals, with the faces possessing the same relative dimensions.

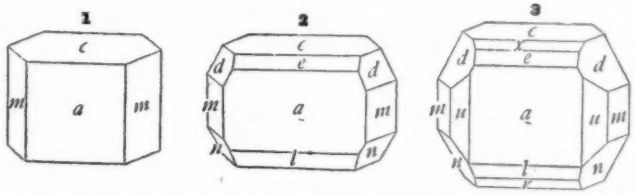


Fig. 1 shows the simplest form, consisting merely of the basal pinacoid (*c*)OP(001), the ortho-pinacoid (*a*)$\infty\bar{P}\bar{\infty}$(100) and the prism (*m*)∞P(110). This simple combination rarely occurs.

Fig. 2 is a combination showing forms (*e*)$-P\bar{\infty}$(101), (*d*)$-$P(111), (*n*)$+$P($\bar{1}$11) and (*l*)2P$\bar{\infty}$(201) in addition to those in fig. 1. This crystal is the largest terminated one in the lot examined and the angles were measured with a contact goniometer.

Fig. 3 shows a much more general combination. The forms occurring are (*c*)OP(001), (*x*)$-\frac{1}{2}P\bar{\infty}$(102), (*e*)$-P\bar{\infty}$(101), (*a*) $\infty\bar{P}\bar{\infty}$(100), (*d*)$-$P(111), (*n*)$+$P($\bar{1}$11), (*u*)$\infty\bar{P}2$(210), (*m*)$\infty$P (110), (*l*)2P$\bar{\infty}$(201) and (*r*)P$\bar{\infty}$($\bar{1}$01). This combination is similar to the one on the large allanite crystal from Moriah, N. Y., described by E. S. Dana,† lacking only the clino-dome P$\bar{\infty}$(011).

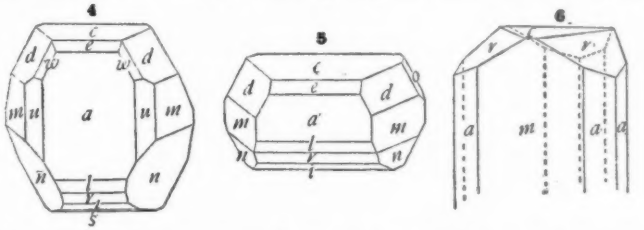


Fig. 4 shows the largest number of forms in combination. All of the forms shown in fig. 3, with the exception of $-\frac{1}{2}P\bar{\infty}$ (102) occur, and in addition (*i*)$\frac{1}{2}P\bar{\infty}$($\bar{1}$02), and the rarer forms (*s*)$\frac{1}{3}P\bar{\infty}$($\bar{1}$03) and (*w*)$-2P\bar{2}$(211).

*W. C. Brögger, Mineralién der sudnorweg augitsyenits, Zeit. für Krys., xvi, 95, 1890.

† E. S. Dana, Allanite, Min. Notes. This Journal, III, vol. xxvii, p. 479.

Fig. 5 is a combination having part of the forms shown in fig. 4, with the addition of the clino-dome $(o)P\,\breve{\infty}(011)$.

The following is a list of the angles measured and calculated:

Faces.	Angles meas.	Angles calc.*
001 : 100	65° 2′	64° 59′
001 : 101	34 50	34 53
001 : 102	22 36	22 $36\frac{1}{2}$
001 : $\bar{2}01$	89 2	89 1
001 : $\bar{1}01$	63 26	63 24
001 : $\bar{1}02$	34 15	34 $15\frac{1}{2}$
001 : $\bar{1}03$	21 22	22 10
001 : 011	58 5	58 $2\frac{2}{3}$
001 : 111	52 $8\frac{1}{2}$	52 9
001 : $\bar{1}11$	74 50	74 49
100 : 101	29 56	30 6
100 : 210	35 42	35 $5\frac{3}{4}$
100 : 111	49 35	49 40
100 : 211	34 9	34 15
100 : 110	54 26	54 34
100 : $\bar{2}01$	25 59	26
210 : 110	19 23	19 $28\frac{1}{4}$
111 : $\bar{1}11$	61 41	61 38
102 : 101	12 18	12 $16\frac{1}{2}$
$\bar{2}01$: $\bar{1}01$	25 $27\frac{1}{2}$	25 37
$\bar{1}01$: $\bar{1}02$	28 13	28 $8\frac{1}{2}$
$\bar{1}02$: $\bar{1}03$	12 27	11 $56\frac{1}{2}$
211 : 111	15 8	15 25

Reflections were so poor in some cases that only approximate readings could be made but a sufficient number of these readings were taken to establish with certainty the identity of all the forms.

The mineral is so opaque and brittle that very thin sections are difficult to obtain. The sections are brown in transmitted light and show strong pleochroism from deep brown to yellowish brown: $\mathfrak{a}$ = yellowish brown; $\mathfrak{b}$ = dark red brown; $\mathfrak{c}$ = dark grayish brown. Absorption $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$. The index of refraction is high while the double refraction appears to be weak. Sections parallel to the orthopinacoid show complete parallel extinction. In the clino-pinacoidal section, the extinction is about 36° from c in the acute angle β. One section, cut parallel to the basal pinacoid, shows a patchwork of reddish-brown and yellowish-green colors resembling an intergrowth. The crystals are abundantly seamed with cleavage cracks and contain many inclusions of the associated feldspar. The optical character of the mineral was not determined.

* E. S. Dana, New System of Mineralogy, 1892, Allanite, p. 522.

On Tourmaline.

An examination was also made of some large tourmaline crystals which came from Rudeville, N. J. This place is about three and one-half miles northeast of Franklin Furnace, and on the same belt of white limestone that contains the zinc ores. The limestone here is pierced by a large dike of so-called mica-diabase, as described by F. L. Nason* and which has lately been shown to contain more or less altered leucites.† The tourmalines occur near the dike and their formation is apparently due to its action. Other green and brown ones of great perfection have been obtained in the white limestone quarry near the furnace at Franklin. They are there associated with a granite dike.

Most of the crystals are dark brown in color and have well defined faces. The largest one in the lot has the common triangular form of prism, bounded by three broad ∞P faces, measuring four inches in width, and narrower ∞P2 faces. The prism is capped by the negative rhombohedron $-$R, and a large basal plane which completely cuts off the polar edges of the rhombohedron. This crystal is shown in fig. 6—$m = \infty P(10\bar{1}0)$; $a = \infty P2(11\bar{2}0)$; $r = -R(01\bar{1}1)$; $c = OP$ (0001).

All of the forms identified on the crystals are as follows:

$\infty P(10\bar{1}0)$	$R(10\bar{1}1)$
$OP(0001)$	$-R(01\bar{1}1)$
$\infty P2(11\bar{2}0)$	$-2R(02\bar{2}1)$
$\infty P\frac{5}{4}(41\bar{5}0)$	$R^5(32\bar{5}1)$

Much assistance has been rendered by Prof. J. F. Kemp, of Columbia College, by suggestions and by the loan of the crystals of allanite and tourmaline which he collected. The writer takes this opportunity to express his acknowledgments.

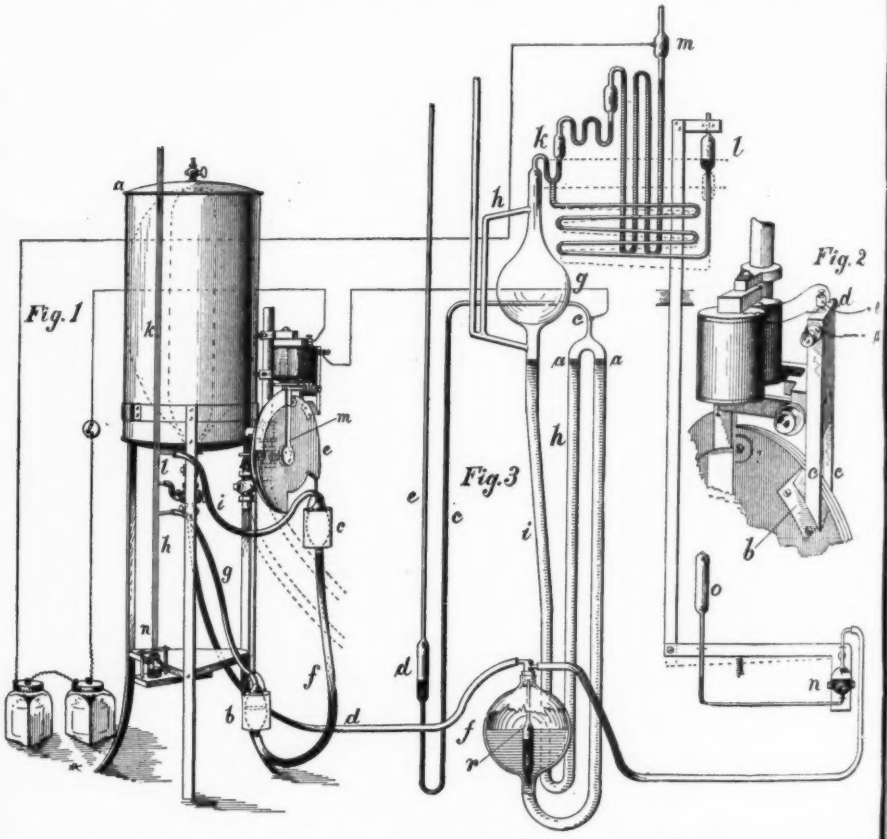
Geological Laboratory, Cornell University.

ART. LIV.—*A Self-Acting Mercurial Air pump;* by EDWARD W. MORLEY, Cleveland, Ohio.

RAPS has devised an excellent self-acting Toepler air pump. But a different method of driving such a pump is sometimes convenient. For instance, the water pressure in my laboratory is not enough to actuate a mercurial air pump, while in the lowest story of the building it will fairly suffice. It is therefore desirable to drive the pump, placed on an upper

* Ann. Rep. State Geologist of N. J., 1890. pp. 35–36.
† J. F. Kemp. This Journal for April, 1894.

floor, by means of an air compressor in the basement. In such a case the apparatus of Raps cannot be used. But with my apparatus, the air compressor and air pump may be separated to any reasonable distance. Further, one air compressor may drive now one air pump and now another, or may drive



several at once, with no change of adjustment other than turning a stopcock and an electrical switch. Also, my apparatus requires no rubber tube in contact with the mercury of the pump.

Two air compressors and three pumps driven by them are in constant and satisfactory use in my laboratory. It is not claimed that the apparatus is superior to the admirable device of Raps, but only that its peculiarities may in some cases be advantageous.

Fig. 1 shows a perspective view of the air compressor. *a* is a copper cylinder: it contains a caoutchouc gas bag which is fastened to a brass tube ending in three stopcocks seen just beneath the cylinder. To two of these are secured tubes which lead to two Toepler pumps: *d* is one of these tubes.

The pulley *e* is attached to the key of a common three-way stopcock. In the position shown, water is admitted to the cylinder; if the pulley and stopcock were turned one-quarter revolution towards the right, the escape would be opened.

The force for turning the pulley is supplied by the weight of mercury in one or the other of the small glass globes *b* and *c*. These are suspended from the pulley by a wire cord: they are connected beneath by the flexible tube *f*. The top of *c* is connected by a flexible tube *i* to a glass tube closed at *l*, and open above. The top of *b* is connected by a flexible tube *g* to the tube *h* and thus to the air in the gas bag in *a*.

The three way stopcock is shown at the instant of opening the admission of water to *a*. The air in the gas bag is therefore at the pressure of the atmosphere, and the mercury stands at the same level in *b* and in the tube *f*. As the air in *a* is compressed, and as the air in the connected Toepler pump is raised, the mercury in *b* is also driven into *c*, and at length fills *c* and rises into the tubes *i* and *l*; *c* thus becomes heavy enough to turn the pulley and stopcock unless prevented. When it is permitted to turn it by descending nearly to the level to which *b* rises, water escapes from the cylinder. The air in the gas bag expands, permitting not only the descent of the mercury in the Toepler pump, but also of the mercury from *c* to *b*. The latter then becomes heavy enough to turn the pulley into its present position; and so the process may be indefinitely repeated.

The release of the pulley when in its present position is controlled electrically. At *m* is a radial arm turning with the pulley and stopcock. It is prevented from turning to the right by the armature of an electro-magnet. The circuit through the coils of this magnet is completed through the mercury of the Toepler pump when this finishes its stroke and discharges itself of air. Some little time before this instant, the loading of *c* is completed: accordingly, at the instant of the discharge and the consequent completion of the circuit, the three-way stopcock turns quickly to the right, water escapes from *a*, the air pressure is relieved, and the mercury descends in the Toepler, and also in the globes *b* and *c*.

It is important that the next ascent of mercury should not begin too soon, but that time should be given for air to flow into the vacuous body of the pump. This is managed by retarding the flow of mercury from *c* back into *b*: they are

therefore placed so as not to differ much in level when *b* is up and *c* is down. The tube *f* is also made rather small, and may be pinched. It is thus easy to make the ingress of air last two seconds, or ten, or a hundred.

Most of the work of my pumps is done during the night and without attention: it is accordingly necessary to restore any air lost from the gas bag by leakage through connections. The tube *h* therefore conveys the air pressure to a small bottle containing mercury. When the air in the system is compressed, this mercury rises in *n*; when the pressure is relieved, this mercury again descends; if air has escaped, the negative pressure on the gas bag caused by the outflow of water draws in air through *n*, and thus keeps up the supply for compression.

It is desirable that no considerable sparking should take place within the Toepler pump. A small current may be sent through a relay, so that the spark in the pump is very small; or the circuit may be broken outside of the pump before it is broken within it. The latter method is used in the air compressor from which the drawing was made. Fig. 2 shows the device used. In the position seen, the circuit is completed from *a*, through the springs *c c* to *d*, by means of the contact piece *b*. If now the circuit is also completed through the pump, the magnet will lift its armature. The pulley will then turn; but before the release of air pressure has begun, the contact piece *b* will have moved away from *c*, and the spark on opening the circuit will therefore occur between *b* and *c* and not within the Toepler pump.

An air trap for Toepler pumps.

In some of the work in my laboratory, a mercurial air pump is required to transfer gas from one vessel to another without admixture with air. To do this with a Toepler pump of the ordinary pattern is practically impossible. Air intrudes between the rubber tube and the mercury which it contains. As soon as the glass tube is slightly fouled, this air insinuates itself between the mercury and the glass and soon rises into the pump body. But a not very complicated addition to the Toepler pump avoids this source of leakage.

The pump from which fig. 3 was drawn avoids contact of rubber and mercury; and it is possible that this source of leakage may not exist. But it nevertheless contains the modification just mentioned. This consists of a second small Toepler pump designed to free from air the mercury which enters the major pump.

The mercury holder *f* is connected to the pump body *g* by a glass tube bent as shown. When the atmospheric pressure

obtains in *f*, the upper level of the mercury is at *a a*. The small tube *c c* is bent upward again, widened at *d*, and continued upward in *e*. When the pump is in action, the space above *a a* is a tolerable vacuum except when filled with mercury. If now air rises with the entering mercury, it is caught in the bend above *a*: it is driven into *c*, forced out to *d*, and escapes through *e*. This being repeated at every stroke of the major pump, no such accumulation of air can take place above *a* as to make possible its passage down *h* and up *i*. This device not only enables me to transfer gas from one vessel to another without admixture, but it contributes to the ease of making high vacua. Some of my work would have been impossible without it.

Discharge of Toepler pump with no compression.

When a Geissler pump is furnished with three stopcocks as is usual now, the pump body is emptied not into the atmosphere but into a good vacuum, and, what is important, the air is discharged without resistance and without consequent compression to a very small volume. But when a Toepler pump is discharged, even with any auxiliary vacuum heretofore described (as far as is known to me), the discharge takes place against the pressure of a short column of mercury, and the air is therefore compressed. There accordingly comes a time when this compressed air has no longer a volume sufficient to ensure its discharge. For instance, one of my pumps will carry an exhaustion to about one part in five million. The amount to be discharged becomes at this tenuity so small that its volume when compressed forms only a little bubble adhering to the side of the tube through which it ought to be discharged. But in my laboratory a device has been used for many years which empties the Toepler pump as completely as the Geissler pump is emptied; and lately this device has been made self-acting. It so much increases the degree of exhaustion which can be attained that it may be useful for some purposes, and is shown in fig. 3. *k* is an enlargement of the tube by which air is discharged from *g*. It is connected by a small glass tube with *l*: the tube is so flexible that *l* can be moved also into the dotted position. To explain its action, let us suppose that the pump is filled with mercury to *m*, and that *l* and the slender connecting tube are also so filled. When now *g* is emptied of mercury, *l* having been placed in the dotted position, will remain filled with mercury to the level of the upper dotted line, and *k* will be shut off from *g*. If now *l* is raised to the upper position, mercury will run out of it, but the passage from *g* to *k* will remain closed. Now, when the mercury

rising for the next stroke has partly filled the pump body g, let l be lowered; the mercury which fills the passage from g to k will run into l and so open this passage. The air in g will therefore be freely discharged into k. The simple raising and lowering of l performs the same function as the use of the third stopcock of the Geissler pump; and it introduces no source of leakage. It very greatly increases the perfection of the vacuum which can be attained with a Toepler pump.

It was hoped to give here the result of a measurement of the efficiency of the same pump with this device alternately active and inactive; but a serious accident makes it at present impossible.

The means by which the motion of l is made automatic is shown at u and o. n contains mercury; it is connected with o and pivotted near n. The air pressure which works the pump is conveyed to n. When the mercury of the pump rises in g, mercury is also driven from n to o; this becomes heavy, draws l downward, and so opens the passage from g to k. This passage as well as l is filled when the air is discharged into k, and remains full when l is raised, to be opened again at the next stroke. The device will no doubt be thought rather fragile: but out of some twenty-five or thirty breakages of Geissler and Toepler pumps in my laboratory, it is the whimsical fact that this is the only part which has not yet been broken.

One less important matter may be mentioned. About twenty Toepler pumps have been broken in my experiments by the impact of ascending mercury against the upper part of the pump body. It was better economy of time to break them than to drive them slowly: but very vexatious. If the attempt is made to avoid breakage from this cause by elongating the upper part of the pump body, so as to give a slow motion to the ascending mercury, a contrary evil is introduced. The descending mercury clings in the tube, and at last falls so heavily as to split the tube p; as has happened to me several times. Now a contrivance has been in use which it is hoped may prevent breakage without retarding the action of the pump. It consists of a float seen at r, fig. 3. This is so adjusted as to settle into the neck of f just before the mercury in g rises to the danger point. The flow of mercury is then checked by the loosely fitting float, and, what is more important, oscillation is prevented. It works well so far, although it has not been long enough in use to warrant confident recommendation. But of the air compressor here described it is proper to speak confidently. The one which has been in use longest often makes twenty thousand strokes without failure or readjustment.

Art. LV.—*New Method of determining the relative Affinities of certain Acids;* by M. Carey Lea.

[Read before the National Academy, April, 1894, by Prof. Ira Remsen.]

This method of measuring affinities is based on the principle that *the affinity of any acid is proportionate to the amount of base which it can retain in the presence of a strong acid selected as a standard of comparison for all acids.* The standard acid being in all cases kept exactly at the same dilution.

An example will make this clearer. Sulphuric acid is here taken as the standard and its presence or absence in the free state is ascertained by means of the herapathite test (described in this Journal, June, 1893). For simplicity we will suppose that the quantity taken is always a gram molecule at a fixed rate of dilution. It is evident that two gram molecules of sodium hydroxide would exactly saturate it. If now we take a given acid we may find that a quantity of its sodium salt corresponding to three gram molecules of sodium hydroxide will exactly extinguish the reaction of a gram molecule of free sulphuric acid. With still another acid we may find that a quantity of its sodium salt corresponding to four gram molecules of sodium hydroxide are needed to extinguish the sulphuric reaction. Then the affinity of the second acid is exactly twice as great as that of the first. At the point where the free sulphuric acid reaction was extinguished the second acid under examination retained twice as much sodium as the first and this quite independently of any question of comparative basicity.

Throughout the series of determinations here to be described the sulphuric acid was used invariably at the same degree of dilution, otherwise the results would not be strictly comparative. Having obtained normal acid by titration with pure sodium carbonate this was further diluted to $\frac{N}{8}$ and 50 to 100^{cc} were found a convenient quantity to employ. The salt to be tested was finely powdered and thoroughly dried at 100°, or at whatever higher temperature it could support. It was then placed in a weighing bottle and cooled in a dessicator and kept there except for a few moments at a time. By using the dry salt the dilution of the acid was kept constant. When the point of extinguishment seemed to be reached, at least four final crystallizations were made. Great care is necessary to seize the exact point of extinguishment. The quantity of the salt found is then reduced to correspond with one gram molecule of sulphuric acid. It is next divided by its own molecu-

lar weight; this gives the number of molecules of the salt needed to extinguish the reaction in one molecule of sulphuric acid. In order to make it possible to compare acids of different basicities, the figures thus obtained must next be modified to correspond with the basicity of the acid used. If the acid is bibasic no change will be needed. If monobasic the figures obtained must be divided by 2. If tribasic they must be multiplied by $\frac{3}{2}$ etc. Finally as the quantity characteristic of the acid is the excess of the quantity found, over the amount equivalent to one molecule of sulphuric acid, unity is deducted from the amount obtained and the residue thus found represents the comparative affinity of the acid and may be called its *index*.

This may be rendered more clear by one or two instances.

In the case of hydrochloric acid there was needed as a mean of many determinations 29·37 gram molecules of sodium chloride to extinguish the reaction in one gram molecule of sulphuric acid. At this point the solution necessarily contained,

$$Na_2SO_4 + 2HCl + 27{\cdot}37NaCl.$$

This is proved beyond question by the fact that the solution no longer gives a trace of reaction of free sulphuric acid. The quantity 27·37 gram molecules of sodium chloride is the proportion of undecomposed sodium chloride that must remain in the solution in order that the sulphuric acid may be completely converted into sodium sulphate and may remain as such in the solution in a condition of equilibrium.

This number 27·37 therefore represents the strength of the affinity of hydrochloric acid for sodium. But in order to compare acids of different basicities it is convenient to refer them all to bibasic sulphuric acid and therefore the number just found must be divided by 2. Therefore 13·68 may be taken as the index of the affinity of hydrochloric acid in comparison with those of other acids determined in like manner.

Similarly with pyrophosphoric acid. The mean value found for the quantity necessary to extinguish the free sulphuric acid in one gram molecule of sulphuric acid was found to be 0·963 gram molecules of sodium pyrophosphate. At this point the liquid contains

$$Na_2SO_4 + \tfrac{1}{2}(H_4P_2O_7) + {\cdot}463(Na_4P_2O_7)$$

in equilibrium. The number ·463 therefore represents the comparative affinity of pyrophosphoric acid except that as the acid is quadrobasic the number found must be multiplied by 2 in order to bring it into comparison with bibasic acids. Therefore the index of pyrophosphoric acid is ·926. This acid being quadrobasic half a molecule contains the quantity of

sodium requisite to saturate a molecule of sulphuric acid and therefore only half a molecule of pyrophosphoric acid is set free.

In other words: it is found by experiment that the quantity of sodium pyrophosphate necessary to extinguish the reaction for free sulphuric acid with 1000 molecules of that acid is 963 molecules; out of this, 500 molecules of pyrophosphoric acid are set free as just mentioned and there remain 463 molecules of undecomposed pyrophosphate. This number 463 multiplied by 2 because of the basicity of the acid and divided by 1000 to make it correspond to one molecule of sulphuric acid gives ·926 as the index of pyrophosphoric acid.

The state of equilibrium is always conditioned by the degree of concentration. If to any solution of sulphuric acid a salt is added in just sufficient quantity to extinguish the sulphuric acid reaction, it is then only necessary to add a little water and the equilibrium is at once changed: a certain portion of the salt that had been added is re-formed and the sulphuric reaction reappears. In order therefore to obtain true comparative results it is necessary to use the sulphuric acid always at exactly the same dilution and to add the dry salt to it.

The affinity of sulphuric acid for water is a most important factor in all determinations of this nature. Mendeleef indeed expresses the opinion* that most of the affinities hitherto determined are unreliable for want of sufficient exactitude in this respect.

To show how much precaution is needed, the following reactions may be mentioned.

When 4^{cc} of normal sulphuric are added to 40^{cc} of normal solution of sodium nitrate not a trace of free sulphuric acid can be detected in the liquid. In consequence of the large excess of sodium salt the sulphuric acid has been completely taken up by the sodium with of course an expulsion of an equivalent quantity of nitric acid.

But when instead of 4^{cc} of normal sulphuric acid we use 40^{cc} of decinormal acid then although the quantities of acid and of salt are exactly the same the equilibrium is completely changed. The greater quantity of water present by reason of its affinity for sulphuric acid counteracts to some extent the affinity of the sodium. Free sulphuric acid exists in the solution and is abundantly indicated by the herapathite test.

This difference may be even more strikingly shown in the following manner. Taking the mixture of 4^{cc} of normal sulphuric acid and 40^{cc} of normal solution of sodium nitrate let a

* Principles of Chemistry, English ed., vol. i, p. 377, footnote.

drop be placed in each of two small porcelain basins previously slightly warmed. To one of them let a single drop of distilled water be added and then the herapathite test to both. In a few minutes the one which has received the drop of water will show well marked crystallizations of herapathite whilst the other will not show a trace.

The effect of dilution in changing the equilibrium of the solution of a base with mixed acids is thus made visible to the eye by a chemical reaction. Hitherto it has been a deduction from physical changes requiring great delicacy of measurement. Results of a precisely similar character were obtained when potassium bromide was substituted for sodium nitrate and are no doubt of general occurrence.

The applicability of this method proved to be a good deal restricted owing to the tendency of many acids when set free to decompose the herapathite reagent. For this reason the affinities of hydrobromic, hydriodic, chloric, iodic and nitric acids could not be measured with accuracy, although many attempts, sometimes as many as 30 or 40 or more were made to get reliable results. This work, however, was not entirely thrown away. It demonstrated that *chloric acid* has the strongest affinity for bases of any known acid. It might have been expected *a priori* that a highly oxidized acid of chlorine would have stronger affinities than chlorine hydride. It also showed that the comparative affinity of nitric acid has hitherto been placed somewhat too high. Taking hydrochloric acid as 100, nitric acid scarcely exceeds 75.

The weaker acids, being for the most part without action on the test solution, give satisfactory results. Oxalic and tartaric acids must, however, be excepted, the acid set free tends to form acid salts of sparing solubility, these are precipitated, thus the conditions are changed.

The results obtained are here tabulated.

Hydrochloric acid	29·37	13·68	100
Succinic	1·21	0·21	1·54
Acetic	2·28	0·14	1·02
Citric	1·02	0·53	3·87
Pyrophosphoric	0·963	0·926	6·77
Tungstic	1·2	0·2	1·46

The first column of this table shows the absolute number of molecules of the sodium salt which must be added without regard to the basicity of its acid in order that one molecule of sulphuric acid may be so completely saturated with base as no longer to give a reaction for free sulphuric acid.

In the second column these numbers are modified in such manner as to cause them to justly represent the comparative affinity of the acid. With monobasic acids the number of molecules is divided by 2, with quadrobasic acids it is multiplied by 2. For a tribasic acid it is multiplied by $\frac{3}{2}$. Bibasic acids only, remain unchanged. Next, unity is subtracted because it is always the excess of the salt which must be present in order to keep the sulphuric acid saturated with base that gives the measure of the affinity of the acid. Were this correction not applied the entire result would be vitiated.

The third column gives the numbers as they appear when hydrochloric acid is taken as 100.

Instead of adding salts of different acids to sulphuric acid, we may add various acids to a salt formed by the union of sulphuric acid to a strong base, for example, to sodium sulphate.

Sulphuric acid is now recognized as being a weaker acid than hydrochloric, and yet we have seen that it is able to detach a certain quantity of base from a chloride. Further, that if the chloride is present in sufficient excess, the sulphuric acid may take up enough base to completely saturate itself. The general fact that a certain quantity of an acid may be expelled from a salt by another acid, even much weaker than the first, has been shown by the researches of Thomsen and of Ostwald. So that if for example we add acetic acid to a solution of sodium sulphate a distinctly recognizable quantity of sulphate is decomposed and converted into acetate. A condition of equilibrium is produced in which the liquid contains both acids in a free state and both salts. In some way that we do not yet understand the presence of the free acid maintains the combined acid in its combination. The sodium acetate exists only by virtue of the free acetic acid present.

The existence of this state of equilibrium was first proved by Thomsen who deduced it from the thermochemical changes which took place on mixing the solutions. Ostwald reached similar conclusions by making accurate determinations of the changes of volume and consequently of specific gravity which resulted from the mixing of the solutions, and in other ways.

In both these cases the conclusions are reached by logical deductions from the phenomena observed. But with the aid of the herapathite test the expulsion of sulphuric acid by a very much weaker acid can be rendered immediately evident to the eye. Thus if to the solution of sodium sulphate we add acetic acid and place two or three drops of the mixture in a warm porcelain basin and add some of the test liquid to it, in a few minutes we have great number of small black rosettes

of herapathite which crystallize out. Solution of sodium sulphate not containing acetic acid gives no such reaction with the herapathite test. It dries up to a pale yellow residue.

Acids vary very much in their ability to detach sulphuric acid from sodium. The following acids when added to sodium sulphate and tested by the herapathite test, give the results here noted.

Malic acid, gives an abundant crystallization.
Succinic acid, acts similarly.
Lactic acid, a moderate reaction.
Mucic acid, about the same as lactic.
Vanadic acid, traces.
Arsenic acid, abundant crystallization.
Hippuric acid, distinct traces.
Salicylic acid, distinct crystallization.

Of course the stronger organic acids, tartaric, oxalic and citric separate sulphuric acid with abundant crystallizations of herapathite when they are made to act on sodium sulphate and the test is applied. It was observed that an acid oxalate acts like a free acid. Thus when a solution of potassium binoxalate or quadroxalate is added to one of sodium sulphate, sulphuric acid is detached precisely as if free oxalic acid had been used.

It is clear that extremely weak acids such as hippuric and salicylic are able to take a certain quantity of base even from so strong an acid as sulphuric, setting free a recognizable quantity of this latter acid. Carbonic acid is still weaker than these. Ostwald in determining the relative affinities of acids by the rate of the decomposition of acetamide and by the inversion of cane sugar found no appreciable effect from carbonic acid. It therefore became of interest to ascertain if any sensible decomposition of sodium sulphate would result from the action of this acid.

Perfectly pure carbonic anhydride was passed for a long time through a solution of sodium sulphate without setting free a recognizable trace of sulphuric acid. This was expected, the experiment was only preliminary to its repetition under pressure.

For this purpose sodium sulphate with the test solution was placed in one leg of a bent tube, in the other leg was placed sodium bicarbonate; and the tube was sealed. Heat was gradually applied to the bicarbonate. In the second trial the pressure was raised so high that the stout glass tube was ultimately shattered with violence. The leg containing the test liquid and sulphate had been secured in a clamp and remained uninjured. The liquid therefore had been subjected to the action of carbonic anhydride at a high pressure—it however

gave no indications of a separation of traces of sulphuric acid under its action. It is to be remarked that this test is more decisive than if a solution of sodium sulphate had been used and had been tested afterwards. For in this last case, on release of the pressure, the reaction might readily be reversed with recombination of sulphuric acid, had any been liberated. But with the test liquid present during the pressure this reversal could not take place.

Carbonic anhydride, therefore, does not even under pressure, set free any portion of sulphuric acid from sodic sulphate.

The reactions described in this paper indicate:

1st. That when to free sulphuric acid a salt is added in sufficient quantity to cause the whole of the sulphuric acid to saturate itself with the salt-base, it is possible by means of the herapathite test to determine the exact point of such saturation. At this point there will necessarily be as much of the acid at first combined with the base, now free in the solution, as corresponds to one molecule of a bibasic acid, that is two of a monobasic acid, half a molecule of a quadrobasic acid, etc. From this we can deduce the exact nature of the resulting equilibrium.

2. That a series of equilibria thus obtained with different salts, enables us to determine the comparative strength of the affinities of the acids of those salts.

3. That the fact, already proved in other ways, that even small quantities of weak acids, added to sulphates will set free a certain quantity of sulphuric acid, can by means here given be for the first time rendered visible to the eye by a well marked chemical reaction.

ART. LVI.—*On Argyrodite and a new Sulphostannate of Silver from Bolivia;* by S. L. PENFIELD.

IN the August number of this Journal, 1893, page 107, the author described as a new species a germanium mineral from Bolivia, to which the name canfieldite was given. It was shown that the mineral was identical with argyrodite in chemical composition, but differed apparently in crystallization, canfieldite being isometric while argyrodite was monoclinic, according to the description of Weisbach.* The discovery of the isometric mineral was communicated by letter to Professor Weisbach, and soon after the publication of the author's article a reply was received from him, in which it was stated that

* Jahrb. f. Min., 1886, ii, p. 67.

better crystals of the Freiberg argyrodite than those originally described had been examined, and the results had shown that they were isometric and tetrahedral. These conclusions have since been published.* The forms *m* and *o* of Weisbach† are regarded as the dodecahedron (110), *f* and *k* as the tetrahedron $x(111)$, $\frac{1}{2}$ and *v* as the negative pyramidal-tetrahedron $x(3\bar{1}1)$ $-\frac{3}{2}$. Argyrodite being isometric it is evident that the Bolivian mineral is not a new species and the name canfieldite is therefore withdrawn. For the sake of simplicity it is a satisfaction to have the Bolivian mineral identical with that from Freiberg, and it is regretted that the isometric character of argyrodite was not made known before the publication of the canfieldite paper. It was hoped that by the present time some definite information could be given concerning this new occurrence of argyrodite, but as yet no data have been received other than that it is a well known silver ore in the mines at Potosi.

There has also recently come into the authors possession, through the kindness of Mr. Wm. E. Hidden of New York, a specimen from La Paz, Bolivia, which was supposed to be argyrodite. Its total weight was a little over seven grams and it consisted of a few attached octahedrons, modified by dodecahedron planes, the largest crystal measuring 13^{mm} in axial diameter. The only visible impurity was a very little metallic silver in wire form, deposited in a few places on the outside of the crystals. The mineral is almost identical with argyrodite in all of its physical properties. The luster is brilliant metallic. Color black with the same bluish to purplish tone observed on argyrodite. The fracture is irregular to small conchoidal. Very brittle. Hardness $2\frac{1}{2}$–3, specific gravity 6·276, that of argyrodite from Bolivia being 6·266. Heated before the blowpipe on charcoal at the tip of the blue cone the mineral fuses at about 2 and yields a coating of the mixed oxides of tin and germanium. This is white to grayish near the assay, tinged on the outer edges with yellow. By continued heating a globule of silver results but this is covered by a scale or coating of tin oxide. If the coating on the charcoal is scraped together and fused in the reducing flame with sodium carbonate globules of tin are formed. In the closed tube sulphur is given off and at a high temperature a slight deposit of germanium sulphide, which fuses to globules, is formed near the assay. In the open tube sulphur dioxide is given off but no sublimate is deposited.

The following method was adopted for the analysis. The mineral was oxidized by concentrated nitric acid and the excess

* Jahrb. f. Min., 1894, i, p. 98.

† Compare figure in Dana's Mineralogy, sixth edition, p. 150.

of the latter removed by evaporation. The residue after moistening with nitric acid was digested with boiling water for some time and the insoluble meta-stannic acid filtered off. This was transferred while still moist to a beaker and treated with strong ammonia into which hydrogen sulphide was conducted until the meta-stannic acid had gone into solution. A slight insoluble residue was filtered off at this point which contained about 0·10 per cent of tin and 0·40 per cent of silver. From the ammonium sulphide solution the tin was precipitated by addition of a little sulphuric acid and weighed as oxide. The filtrate from the stannic sulphide was evaporated and yielded a little germanium which had not been separated from the tin by the nitric acid treatment. In the original filtrate from the meta-stannic acid silver was precipitated by means of hydrochloric acid and weighed as chloride. The sulphur was next precipitated by barium nitrate, and after purifying by fusion with sodium carbonate weighed as barium sulphate. Before evaporating the filtrates hydrochloric acid and barium were removed by precipitation with silver nitrate and sulphuric acid. The excess of silver was finally removed by ammonium thiocyanate and the germanium obtained from the filtrate as described in a previous communication.* The results of the analysis are as follows:

			Ratio.		Theory for $Ag_8(SnGe)S_6$ where Sn : Ge = 12 : 5.
S	16·22	·507		5·92	16·56
Sn	6·94	·0589	·0842	0·98	7·18
Ge	1·82	·0253			1·83
Ag	74·10	·686		8·00	74·43
Zn and Fe	·21				----
	99·29				100·00

In this compound tin is undoubtedly isomorphous with germanium, and the two are present in about the proportion 12 : 5. The ratio of S : Sn+Ge : Ag in the analysis is very close to 6 : 1 : 8, indicating that the formula is $Ag_8(SnGe)S_6$ or $4Ag_2S . (Sn . Ge)S_2$. The agreement between the theory and the analysis is satisfactory.

The only sulpho stannates thus far known to occur in nature are the rare species *stannite*, Cu_2S, FeS, SnS_2, *franckeite*, 5PbS, Sb_2S_3, $2SnS_2$ and *plumbostannite* a mineral of doubtful composition containing Pb . Fe . Sb . and S, described by Raimondi.† Franckeite has recently been described by Stelzner‡ and in it Winkler was able to identify a small amount of ger-

* This Journal, xlvi, p. 111, 1893.
† Zeitschr. Kryst., vi. p. 632, 1882.
‡ Jahrb. Min., 1893, II, p. 114.

manium, probably about 0·10 per cent. These authors call attention to the fact that since tin and germanium belong to the same chemical group they are isomorphous with one another and suggest the probability of finding in Bolivia a sulpho-stannate of silver isomorphous with argyrodite. The new mineral described in this article corresponds precisely to this idea. As the Freiberg argyrodite has been shown to be isometric, and the name *canfieldite* cannot therefore be applied to the germanium compound, it is proposed now to transfer the name to the new isomorphous tin compound. It is not probable that this will cause confusion as the name as at first applied was not long in use and has never been introduced into any of the text-books or systems of mineralogy, and especially as it is now transferred to a species which is very closely related, and should come next to argyrodite in a natural system of classification. It is probable that various mixtures of argyrodite Ag_8GeS_6 and the molecule Ag_8SnS_6 will be found and it would seem best to consider this latter as the canfieldite molecule, while the intermediate isomorphous mixtures would be called argyrodite or canfieldite, according as the germanium or the tin molecule predominated.

Regarding the crystallization of the argyrodite and canfieldite from Bolivia the specimens examined by the author, are apparently holohedral. The octahedron faces are equally developed and have the same luster. There is, however, on each of the dodecahedral faces of the canfieldite specimen a distinct furrow or slight depression running in the direction of the longest diagonal. This may indicate a twinning which has given rise to the apparently holohedral form, or the latter may of course have resulted from an equal development of positive and negative tetrahedrons.

Laboratory of Mineralogy and Petrography,
Sheffield Scientific School, New Haven, April, 1894.

Art. LVII.—*On the Damping of Bell-magnets and Ring-magnets by surrounding copper;* by Arthur Kendrick.

This paper presents the results of some observations made by the writer at various times upon the damping of bell-magnets and ring-magnets in copper boxes with the view of ascertaining roughly the relations between magnetic moment, inertia moment, and size and shape of the surrounding copper.

The accompanying figures show at a glance the dimensions of the magnets and some of the boxes used. Figures 1, 3, 4 and 9 show vertical and horizontal sections, fig. 2, a horizontal

FIG. 1.

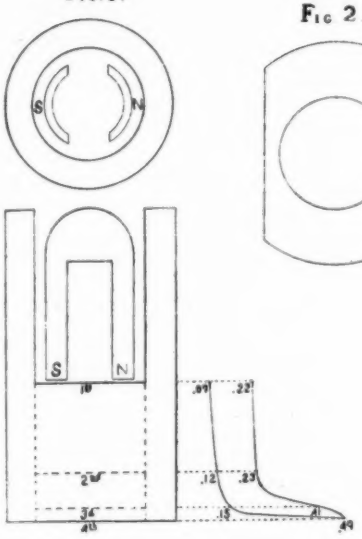


FIG. 2.

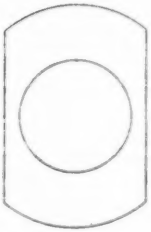


FIG. 3.

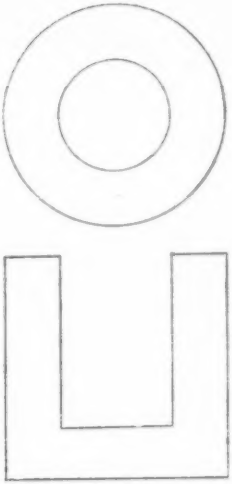


FIG. 5.

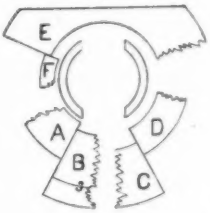


FIG. 4.

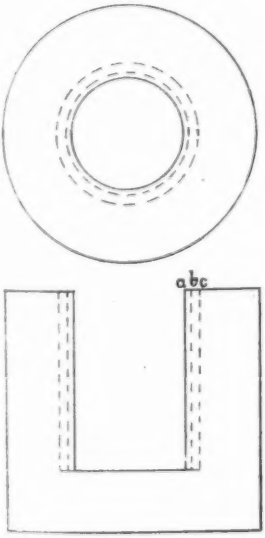
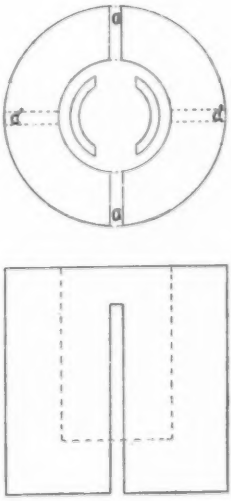


FIG. 6.



section, and fig. 6, horizontal section and side elevation (without perspective) of cylindrical boxes for the bell-magnets. Similarly the bell-magnets are shown, p. 461, by horizontal sections and side elevations. The suspension was a raw silk fiber whose torsional effect can practically be ignored, though it was quite appreciable in the cases of the smallest magnets. The restoring force, unless otherwise stated, is understood to be the earth's field, which has at the point where the needles were suspended a horizontal intensity of about .16 dyne per unit pole.

As a measure of the damping that occurs in a succession of vibrations, I will use the average of the ratios of each amplitude to the preceding amplitude taken from a number of successive swings and call this Δ. Its reciprocal is approximately the logarithmic decrement, but this ratio is more convenient, especially for plotting, as the values must lie between 0 and 1, instead of between ∞ and 1. The lower limit signifies "dead-beat" vibration, and the upper limit, no damping. A value of Δ less than 0·1 means for most work very good damping. Since some of the following comparisons are made by referring to the number of swings (half vibrations) that the needle, after disturbance, makes before coming to rest, it may be useful to write a table giving approximately the values of Δ corresponding to these. The scale used in reading deflections was divided into millimeters (scale distance about 65^{cm}), and the readings made to two-tenths of a millimeter. Then with a moderate initial disturbance of the needle, say about 200^{mm}, if the vibrations decease to less than two-tenths of a millimeter in

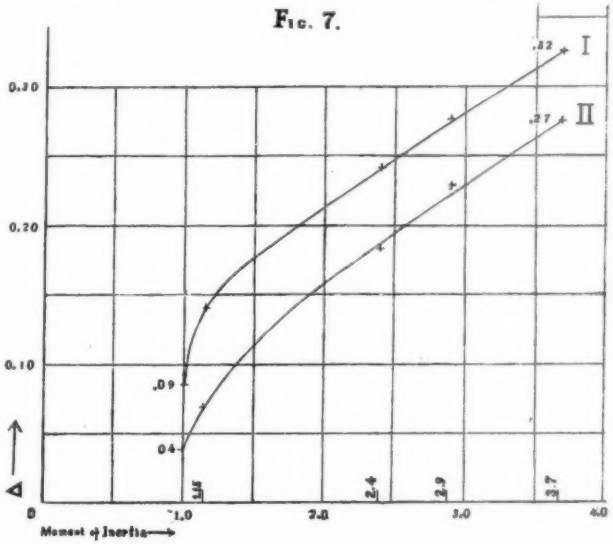
5	swings,	Δ	is about	0·20
6	"	"	"	0·25
7	"	"	"	0·35
8	"	"	"	0·40
10	"	"	"	0·45
11	"	"	"	0·50
15	"	"	"	0·60
20	"	"	"	0·70
33	"	"	"	0·80

Let any copper box be designated by the number of the figure that represents it, and any magnet by its letter.

Magnet Q was used under a larger variety of conditions than any of the others. These varying conditions were: five different moments of inertia of relative values 1·0, 1·15, 2·4, 2·9, 3·7, the first being that of the magnet, mirror and suspension, and the others were produced by the addition of inertia discs; three magnetic moments of relative values 0·44, 0·68, 1·0, the

latter being, apparently, the greatest possible permanent moment for Q, its value, about 52^{cgs} units; the earth's field and a considerably weakened field; a variety of shapes and sizes of the copper boxes, and one box of brass. Box 1 was bored to successive depths 1st, 2d, 3d, 4th as shown in fig. 1, the 4th meaning that it was bored quite through. Box 4 was given successive interior diameters, *a*, *b*, *c*. With 1 (1st), 3 and 4 (*a*), all of the same interior diameter, the Δ's were found for the five different inertia moments and the three magnetic moments. Using the Δ's for ordinates and the relative inertia moments for abscissas and plotting a curve for each of the three boxes for each magnetic moment there results nine curves, or three sets (corresponding to the magnetic moments) of three curves each (each curve of a set corresponding to a box). Fig. 7 presents two of these curves. I is plotted from

Fig. 7.



Δ's given by Q in box 1 (1st) with relative magnetic moment 1·0, and II, from Q in boxes 3 and 4 (*a*), (these two giving nearly the same damping). The two other sets of curves from relative magnet moments 0·68 and 0·44 would be located respectively above curves I and II and are very similar to them. The relative moments of inertia are plotted as abscissæ and the Δ's as ordinates. Plotting the relative magnetic moments of Q as abscissæ and the Δ's as ordinates, and using relative inertia moment 3·7 and box 1 (1st), we get I of fig. 8;

with box 1 (1st) and inertia moment 1·0, curve III; and similarly with box 3 (or 4*a*) curves II and IV respectively for the inertia moments 3·7 and 1·0. [The ordinate of the lower end of curve II, fig. 8, should read ·27 instead of ·21.]

FIG. 8.

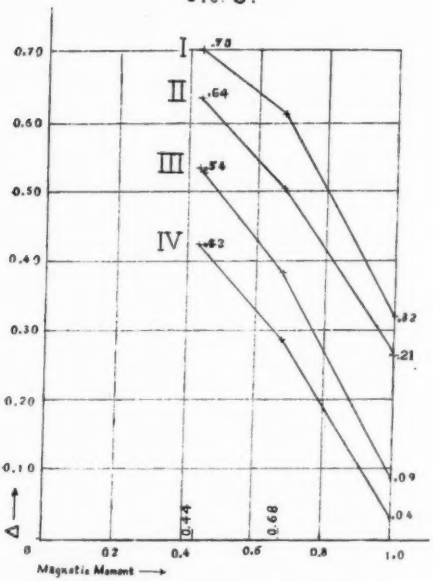
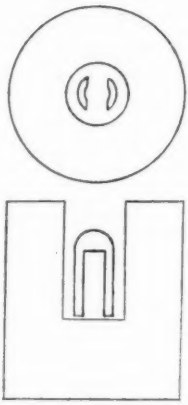


FIG. 9.



Several things appear from these curves. The damping due to these boxes is similar; it is appreciably less in box 1 than in 3 and 4 (*a*), and almost inappreciably less in 3 than in 4 (*a*), so the extra thickness of 4*a* is superfluous; when the moment of inertia and magnetic moment are both 1·0, box 1 (1st) gives $\Delta = 0{\cdot}09$ and boxes 3 and 4 (*a*) give $\Lambda = 0{\cdot}04$, the latter practically aperiodic, and the former very satisfactory damping; a comparatively slight increase of the greatest magnetic moment or slight decrease of the least inertia moment would give "dead-beat" vibration; the rate of decrease of Δ with respect to increase of relative magnetic moment is greater than the rate of decrease of Δ with respect to decrease of relative inertia moment.

In what follows Q is used with relative inertia moment and relative magnetic moment each equal to unity.

The effect of the thickness of the copper in the bottom of these boxes is indicated by fig. 1. Box 1 was used successively with the three thicknesses of bottom shown in fig. 1, and

fourthly with the bottom bored through. The Δ's as abscissæ and thicknesses of bottom as ordinates give the first curve on the right in fig. 1, and the second curve is for the values of Δ when the needle was at the same heights and the bottom bored through. The advantage of having at least a slight thickness of copper in the bottom is evident from the curves. The effect of a thick plate of copper alone such as box 3 inverted under the needle is slight, Δ being about 0·75.

An idea of the relative effect of various outside and inside diameters of the damping boxes is given by fig. 5, where each pair of adjacent segments represents sections of those boxes that give nearly the same damping effects. Thus, A and B give Δ=0·04, C and D give Δ=0·12, E and F give Δ=0·18. D is box 1 (2d), C is 4 (*c*); B is 3 and 4 (*a*), and A is a box of outside diameter equal to D but smaller inside diameter. E is box 2, described in the following paragraph, and F is box A turned down to smaller outside diameter. The thickness of the bottom of all these is about the same. The space for the magnet in A and F is too small for convenient leveling, in C it is larger than necessary.

Box 2 is of like dimensions with 3 but planed down on two faces. This gave Δ=0·18, and the direction of the longer transverse axis was immaterial. It should not be inferred, of course, from this that the same effect would be obtained from a circular cylinder of the radial dimensions of the shorter axis. In fact very nearly the same damping was given by a circular box of 2^{mm} thickness and inside diameter of 2^{mm} less than that of box 2. This is shown by E and F of fig. 5.

Fig. 6 gives horizontal section and vertical elevation of a box like 3, but slit nearly through vertically. *aa* and *a'a'* are positions of the slit respectively perpendicular and parallel to the needle's magnetic axis when at rest. In the position *aa* Δ was 0·60, and in the position *a'a'* Δ was 0·04, the same as when there was no slit. This box was afterward slit completely through. With both halves in position *a'a'* the needle came to rest in 4 swings, with one-half in 7 swings. In position *aa*, both halves, 19 swings: one-half, 37 swings.

With a brass box of same outside diameter as 3, bored through, inside diameter 2^{mm} less than that of 3, Δ was about 0·80. Comparing this with 1 (4th), brass is seen to be decidedly inferior to copper as a damping material.

With a stronger field the Δ's are of course larger, with a weakened field smaller, and for Q in all of the above mentioned boxes, except the brass one, the swing may be made "dead-beat." The time of swing is, however, lengthened with increased damping, and this is the more noticeable the smaller the moment of inertia. This seems to show that the effect of

reducing the inertia moment below the point required for "dead-beat" vibration would be to increase the time of coming to rest. With a field of about $\frac{1}{18}$ the value of the earth's field, the time of a half vibration of Q in air was 5 seconds, and in box 4, the vibration being "dead-beat," it required about 30 seconds to come to rest, but with an inertia disc, that increased the time in air to 10 seconds, the time of coming to rest was about 30 seconds. In 4 (*c*) in the same field without the inertia disc, the vibration being also "dead-beat," the time was lengthened only about 2 seconds.

The foregoing results were, as above stated, obtained by using the magnet Q only, and similar action would naturally be expected from other bell-magnets and corresponding boxes, but it may be of interest to mention other forms and sizes that were tried. T is of about one-half the linear dimensions of Q (thickness about the same). Its time of swing in air was nearly the same as that of Q when in the same field, hence the ratio of inertia moment to magnetic moment for the two suspended systems was about the same. But the magnetic moment of T is about $\frac{1}{18}$ of that of Q, hence the inertia moment is about $\frac{1}{10}$ that of Q. Supposing Q in box 1 (1st), if reduced to $\frac{1}{18}$ in relative magnetic moment and relative inertia moment, to represent T in box 7. Producing curve III of fig. 8, so that it will include the point where the magnetic moment is 0·1, we find the corresponding Δ is about 0·65. We see from curve I of fig. 7 that a reduction of the moment of inertia to 0·1 would *at least* reduce Δ from 0·09 to 0, and, without attempting to make any allowance for a further effect, if we subtract 0·09 from 0·65 we get as an estimated value of Δ for T in box 7 something less than 0·6. It was found to be slightly under 0·50. S is twice as long as T, and slightly thicker. The time of swing is a trifle less than that of T, and so its magnetic moment is greater in proportion to its inertia moment; also, since its inertia moment is necessarily somewhat greater than that of T, the magnetic moment is greater, and in the same box, 7, we should expect a value of Δ noticeably less than for T. The observed value is 0·40. In a weakened field, the vibration of T became aperiodic in box 7 and the time of coming to rest was very long. P had a magnetic moment of about $\frac{9}{10}$ that of Q, and an inertia moment about 3·8 times that of Q. Estimating from the curves II of fig. 7 and IV of fig. 8, one would say that the Δ of P in 4 (*c*) might be about 0·40. It came to rest in 11 swings, or Δ was approximately 0·5. U has about $\frac{1}{3}$ the moment of inertia of Q, and about $\frac{4}{10}$ its magnetic moment; 0·4 would be the estimate for Δ of U in box 3, and 10 swings or approximately 0·45 for Δ was the actual damping. R has a moment of inertia about $\frac{6}{10}$

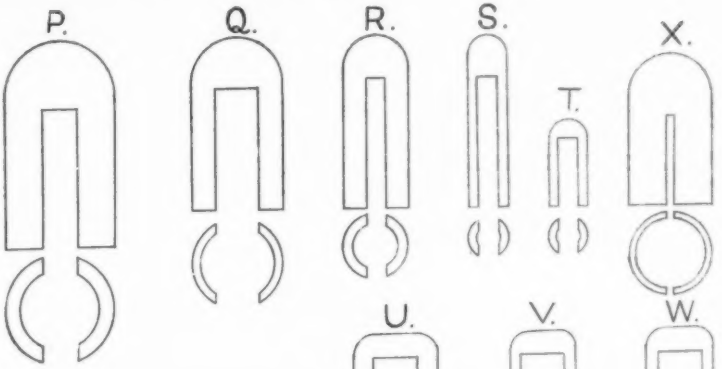
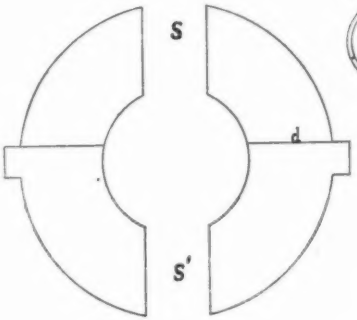


Fig. 13.



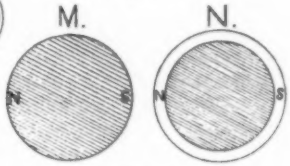


Fig. 11

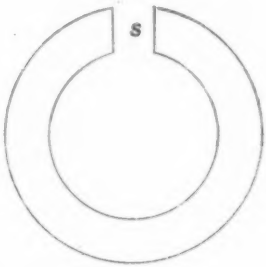
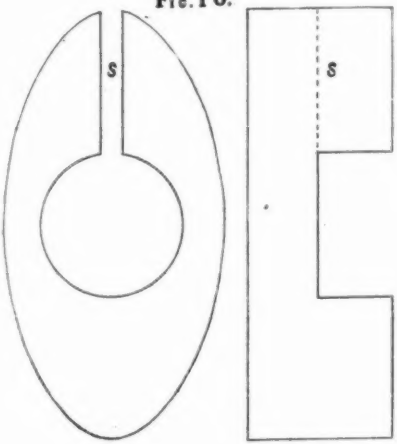


Fig. 10.



11.

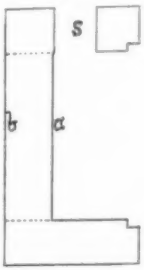


Fig 12.

that of Q and a magnetic moment of about $\frac{8}{17}$ that of Q. Δ would be estimated at about 0·35, and from observation it is 0·33. In the series of magnets U, V, W, the magnetic moment is not reduced as rapidly as the inertia moment, and consequently the damping is maintained, the values of Δ in box 3 being given by 10, 10, 11 swings respectively. X has a magnetic moment about equal to that of W. Its inertia moment is evidently far greater than W's. It came to rest in box 3 in 25 swings. Though these estimates of probable damping in the cases just cited are extremely rough, they seemed to the writer to confirm the natural assumption that the damping of any one of these bell-magnets under varying conditions would be typical, and the results would be applicable in general.

Figures 10 and 11 show transverse vertical sections of copper boxes for the circular magnets M and N, 10 belongs to a galvanometer of F. Kohlrausch's pattern. The slot, *s*, is for the suspension wire and fiber, and extends inward from the front face to the same depth as the hole in which the needle swings. 11 (*a*) is a copper cylinder of the same outside diameter as 4. The suspension hangs through a small hole, *s*, in the top, 11 (*b*) is the same but bored through. 12 is similar to 11 (*a*) but smaller. 13 is a vertical section through the center of a spherical copper box, with spherical cavity. The shell is divided in two by a horizontal plane, *d*, just above the flange, the upper portion resting on the lower. Here also *s* and *s'* are holes for the suspension and support respectively. M is a circular steel mirror 0·8^{mm} thick. N is a ring of rectangular cross section 2^{mm} thick, with plane glass mirror within. The magnetic moment of M was about 12·7^{cgs} units, and of N, 17·2^{cgs} units. The ratio of the moments of inertia of N to M was estimated at about $3 \div 5$. The following table gives in number of swings the damping of each needle by each of these boxes (excepting M in 11 (*b*)).

	Box 10.	Box 11 (*a*).	Box 11 (*b*).	Box 12.	Box 13.
M	7	10	--	7	15
N	5	7	8	5	10

From this it is readily seen that the damping of this ring was more rapid than that of the mirror, that the elliptical box is not superior to the smaller circular box, that the boring through of 11 (*b*) did not render it much inferior to 11 (*a*). One would suppose that the slot in the upper part of 10 would perceptibly impair its damping effect. Accordingly a box like 9 (*a*) was taken and the bottom wall slit through vertically from front to back. The damping of N in this is represented

by 8 swings, in 11 (*a*) by 7 swings. The same slit was continued through the back and the result was 13 swings. With another box the side walls were slit horizontally, result 11 swings. These horizontal slits were then continued through the back nearly meeting, result 18 swings. With the slit extended through and the upper half alone used the number of swings was 34. The faces of the plane *d* of 13 had been lacquered, and the effect of the horizontal slitting just described would indicate that this separation of the halves of the sphere has a very noticeable effect in reducing the damping power.

These observations do not furnish sufficient data for attempting to express in the differential equation of motion of a vibrating magnet the functions representing the damping, but they may possibly prove useful in the way of practical suggestion, and it is with that hope that the paper is written.

Jefferson Physical Laboratory, Cambridge, March, 1894.

ART. LVIII.—*On Thallium Triiodide and its Relation to the Alkali-Metal Triiodides;* by H. L. WELLS and S. L. PENFIELD.

THE well-known resemblance between the thallous salts and many of the corresponding alkali-metal salts has led us to prepare thallium triiodide and to compare its crystalline form with that of the alkali-metal triiodides.* As a result, it has been found that TlI_3 agrees, with remarkable closeness, in form with RbI_3 and CsI_3, and thus a case of isomorphism is established between the higher iodides of thallium and the alkali-metals.

This isomorphism is of special interest because our study of the trihalogen compounds of cæsium has led us to the conclusion that these have the structure of double-salts. We consider the evidence of this double-salt structure as very strong, and since it seems necessary to infer that isomorphism indicates the same arrangement of the atoms, we are obliged, in spite of the apparent trivalence of thallium in thallic compounds, to conclude that TlI_3 is also a double-salt, to which the formula $TlI.I_2$ should be given. It is not safe to assert at present that all thallic salts must be similarly constituted, for it is possible that thallium triiodide is not a true thallic compound at all, and that thallic sulphate, nitrate, etc., have an entirely different kind of structure. If it is granted that

* This Journal, III, xliii, 17 and 475.

thallium triiodide is a double-salt, it seems probable that many other compounds, which are considered as showing higher valence of elements, may in reality have the structure of double-salts or "addition products."

Thallium triiodide was first described by Nicklès* who prepared it by evaporating an etherial solution of thallous iodide and iodine. Nicklès states that he did not obtain it in a pure condition, but that his product always contained an excess of iodine. He described its crystalline form, and his results will be mentioned beyond.

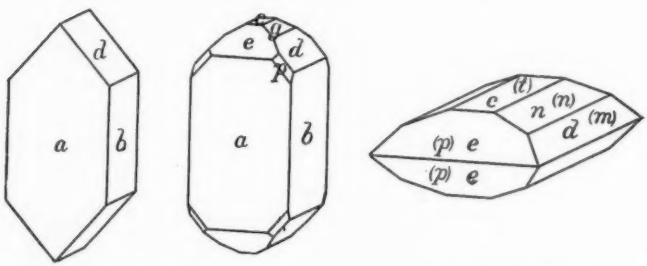
We have modified Nicklès' method by using alcohol as a solvent and have encountered no difficulty in obtaining a pure product. The amount of iodine used was slightly in excess of the calculated quantity, and the solution, produced after long digestion, was evaporated over sulphuric acid until crystallization took place. The resulting crystals were frequently of large size, perfectly black with a magnificent luster which was slowly lost upon exposure. A sample of the salt, simply pressed upon paper, gave the following results upon analysis:

	Found.	Calculated for TlI_3.
Thallium	34·22	34·87
Iodine	64·80	65·13

An examination of the crystals has shown that they are orthorhombic and isomorphous with the orthorhombic alkali-metal trihalides. Moreover, all the forms which have been observed have also been found on the alkali-metal salts, and are as follows:

a, 100, i-$\bar{i}$ *c*, 001, *o* *d*, 011, 1-$\check{}$ *p*, 111, 1
b, 010, i-$\check{}$ *g*, 012, $\frac{1}{2}$-$\bar{i}$ *e*, 102, $\frac{1}{2}$-$\bar{i}$

1. 2. 3.



The habit is shown in figures 1 and 2, the latter being remarkably like that of CsI_3 when this had been crystallized

* J. Pharm. [4], 1, 25.

from alcohol. The measurements which were chosen as fundamental are $d \wedge d$, $011 \wedge 0\bar{1}1 = 96° 34'$ and $e \wedge e$, $102 \wedge \bar{1}02 = 78° 48'$ giving the axial ratio:

$$\breve{a} : \bar{b} : \dot{c} = 0{\cdot}6828 : 1 : 1{\cdot}1217$$

The dome g was determined by the measurement $g \wedge g$, $012 \wedge 0\bar{1}2 = 58° 34'$, calculated $58° 34'$ and the pyramid p by its position in the zones $a-d$ and $d-e$.

A description of this salt, including a figure, has been given by Nicklès. His salt, crystallized from ether, had the habit shown in fig. 3, the letters in brackets being those used by him and the position being changed to correspond with the orientation of the alkali metal trihalides. He considered p as a prism, t as a macropinacoid and m and n as brachydomes. No calculations are given and only the following four measurements:

Nicklès.	Measured.	Calculated from author's measurement.
$p \wedge p$ =	100° 15′,	101° 12′ for $e \wedge e$, $102 \wedge 10\bar{2}$
$p \wedge t$ =	39 22,	39 24 " $e \wedge c$, $102 \wedge 001$
$p \wedge m$ =	61	59 3 " $e \wedge d$, $102 \wedge 011$
$n \wedge t$ =	19 25,	20 30 " $013 \wedge 001$

The agreement between the measured and calculated angles is not very close, but Nicklès' measurements cannot be very exact, for if we take $p \wedge t = 39° 22'$ and $n \wedge t = 19° 25'$ as fundamental, we find by calculation $p \wedge p = 101° 16'$ and $p \wedge m = 57° 55'$, which vary considerably from his measurements. Nicklès crystals differ from ours not only in habit but in having the one-third brachydome n, 013, which has not been observed either in the TlI_3 prepared from alcohol or on any of the alkali-metal trihalides prepared by us.

The very close agreement between the forms of rubidium, cæsium and thallium triiodides is to be seen from the following table of axial ratios:

RbI_3	$\breve{a} : \bar{b} : \dot{c} = 0{\cdot}6858 : 1 : 1{\cdot}1234$
CsI_3	" " " $= 0{\cdot}6824 : 1 : 1{\cdot}1051$
TlI_3	" " " $= 0{\cdot}6828 : 1 : 1{\cdot}1217$

Our previous observation, that the exchange of one metal for another in the trihalogen compounds usually has little or no effect upon the crystalline form, is strongly confirmed by these ratios, and the remarkable agreement between the rubidium triiodide and the thallium compound is very striking when the great difference between the atomic weights of the two metals is considered.

It was hoped that a pentaiodide of thallium could be prepared in order that its form might be compared with that of

cæsium pentaiodide, but by the use of increasing proportions of iodine with thallium triiodide in alcoholic solutions no evidence of the existence of such a compound could be obtained.

The remarkably close relations of thallium to the alkali-metals as far as the thallous compounds are concerned, and the additional resemblance which has been pointed out in the present communication, have led us to consider the possibility that thallium has been wrongly placed in the periodic system of the elements and that it really belongs to the alkali-metals. There are two vacancies in Mendeléeff's table in the alkali-metal group corresponding to atomic weights of about 170 and 220. One of these is smaller, the other larger than the accepted atomic weight of thallium, so that, as far as these numbers are concerned thallium might be composed of two alkali-metal elements. Although the probability that thallium was composed of two elements seemed very slight from other considerations, we have deemed it desirable to test the question experimentally.

About 200 grms. of thallium were converted into the nitrate and this was systematically fractionated by crystallization until about one-twentieth of the salt remained as a repeatedly recrystallized portion and about another twentieth was contained in a final mother-liquor. From each of these two fractions thallous chloride was prepared by converting into sulphate, precipitating impurities with hydrogen sulphide, and finally precipitating thallous chloride by means of hydrochloric acid. The preparations were carefully washed, dried at 100°, and the chlorine was determined as silver chloride in order to get the atomic weight of the metal in each fraction. The silver chloride was weighed in the Gooch crucible, a method which can be most highly recommended for accurately weighing this substance. The following results were obtained, the weights being given as taken in air.

	Crystallized End.	Soluble End.
TlCl taken	3·9146 g.	3·3415 g.
AgCl obtained	2·3393	1·9968
Atomic weight of Tl, (0 = 16),	204·5	204·5

It was not expected that absolute accuracy in the atomic weight of thallium would be attained, but since the same method of purification and analysis was used in both cases the two results are comparable with each other, and their exact agreement shows that the fractionation of the nitrate gives no change in the atomic weight of thallium, and no evidence has been obtained that thallium is not homogeneous.

Sheffield Scientific School, New Haven, Conn., January, 1894.

ART. LIX. — *Notes on the Gold Ores of California;* by H. W. TURNER.

As is well known gold occurs chiefly in quartz veins and these in California have been found to be largest and richest in the slate series of the Sierra Nevada, but gold occurs in a great variety of rocks and associated with very different minerals.

The occurrences will be grouped geologically.

Veins in the auriferous slate series.—Most of the richest gold mines of California occur in the auriferous slates, and in the associated greenstone slates which are, to a considerable extent, metamorphic forms of diabases and porphyrites. The richest single belt of mines is that along the Mother lode, which consists of a series of quartz veins chiefly in a belt of clay slates of Jurassic age, which are designated on the maps of the United States Geological Survey as the "Mariposa slates." The quartz veins are not, however, entirely in these clay slates. In the southern part of Calaveras county and in part of Tuolumne county, the lode lies to the east of this clay slate belt, chiefly in amphibolite-schists. At many points, as at Carson hill in Calaveras county and at Quartz mountain in Tuolumne county, the quartz masses are very large. At other points the quartz occurs in little veins and stringers, through a mineralized zone of the black slate, which then forms part of the vein. In some such occurrences the iron sulphurets containing gold are found both in the slate and in the quartz, and all the material is treated as ore.

Accompanying the Mother lode quartz veins at many points is a green micaceous mineral, containing chromium and called mariposite by Silliman,* who states that so far as he observed, this mineral accompanied the quartz veins only in the neighborhood of magnesian and chloritic rocks.

Prof. Silliman also states that the white magnesian mineral associated with the mariposite is ankerite. Other minerals found by the same author along the Mother lode are ordinary iron and copper sulphides, antimonial copper sulphides, antimonial lead sulphides, and various tellurides. Prof. Silliman also identified somewhat doubtfully tetrahedrite or gray copper ore at the Rawhide mine in Tuolumne county.

Prof. F. A. Genth† states that petzite, telluride of gold and silver; calaverite, telluride of gold; altaite, telluride of lead; and melonite, telluride of nickel, occur at various mines of the Mother lode in the area of the Stanislaus drainage.

* Proc. Cala. Acad. Sci., vol. iii, p. 381.
† This Journal, vol. xlv, II, p. 321.

Prof. W. P. Blake* states that blende and tetrahedrite are found at Carson hill, and in the Pine Tree mine in Mariposa county. The latter mine directly adjoins the Josephine.

Associated with Mariposite at the Josephine mine in Mariposa county, and at Quartz mountain in Tuolumne county, is a white mineral which at some points appears to form veins in the mariposite. This is probably the mineral called ankerite by Silliman. An examination of this material by Dr. Hillebrand shows that it is ordinary dolomite mixed with quartz and not ankerite. In the Josephine mine erythrite, a hydrous arsenate of cobalt, forms on surfaces and in seams of the rock adjoining the vein.

In addition to the ordinary iron sulphurets, the writer has observed in the Mother lode ores in Amador county, galena, blende, and arsenical sulphurets in small amounts. As a general rule the ore of the large mines of the Mother lode show no free gold and only iron sulphurets. Specimens showing free gold and other than iron sulphides are not abundant. All of the Mother lode ore would be called free milling.

In the Paleozoic schists to the east of the Mother lode there are numerous gold veins which have been worked with varying success. One of the most profitable of this group of mines is the Sheep ranch mine of Calaveras county. The country rock of this mine is a mica-schist. The mines about Summersville in Tuolumne county are also in mica-schist. In these mines likewise the sulphurets do not exist as a rule in large amount and the ores may be classed as free milling. One of the most interesting of the mines of this group is the Blue Wing vein of the Willard Mining Company, north of Murphy's, Calaveras county. Here in limestone is a quartz vein which in places is accompanied by brown vein jasper. In the Blue Wing vein are found the sulphides of mercury and antimony and lead. Birdseye porphyry, in this case probably an altered diorite, cuts the limestone in dikes. In the highly altered slates and eruptive rocks to the west of Blue mountain in Calaveras county are a group of mines, the ores of which are very basic. Sulphides containing lead, silver, zinc, arsenic and iron are found in the ore. At the Bonanza mine at Sonora in Tuolumne county the ore occurs in pockets along a diorite dike in the slates. Large masses of free gold with tellurides occur here and iron and copper sulphides.

At the Ilex mine in Calaveras county in Paleozoic mica-chlorite-schist there is a large quartz vein having a course N. 80° E. Tetrahedrite and sulphides of lead, zinc and copper, as well as free gold, are found sparingly in the ore.

* California Minerals, Sacramento, 1866.

Forming the crest of the Sierra Nevada to the east of Yosemite valley is a belt of schists of unknown age. Mt. Dana and Mt. Lyell are culminating points of this area of schists, which extends at least twelve miles northwest of Mt. Dana and judging from the reports of the State Mineralogist at least as far south as the Minarets. This schist belt contains deposits of base ores at numerous points. Specimens obtained by the writer from the Tioga district to the northwest of Mt. Dana, and from Mono pass, show that the bulk of the ores are very rich in sulphides and would probably be difficult of reduction. These ores contain gold and silver, cobaltite, and sulphides of antimony, lead, zinc, copper and iron. One specimen of quartz from the Tioga mine shows a notable quantity of pyrrhotite.

The report of Mr. E. B. Preston* on the silver ores of the Minarets mining district indicate that the ores are very similar to those above described.

At Mineral King, about fifteen miles southwest of Mount Whitney is a body of Triassic schists enclosed in the granite, and containing some gold quartz veins. At the upper workings of the Empire mine there is a small quartz vein in crystalline limestone.

Blende and galena occur in the limestone and blende in the quartz. The mines at Mineral King have not proved profitable, but the district about Tioga and Lundy is a promising one.

Veins in the Granite.—The greater portion of the higher part of the Sierra Nevada and nearly the entire mass of it to the south of Mariposa county is composed of granite. In this large granite area very few auriferous quartz veins have been found. In many of the smaller areas, however, entirely or partly enclosed in the auriferous slate series, there are numerous veins frequently containing abundant gold. Two of these enclosed granite areas have been extensively exploited, that about West Point in Calaveras county and about Soulsbyville in Tuolumne county.

In a general way the ores of the granite districts are very base, and need chlorination to obtain the gold, but this rule is by no means universal.

The ores of the mines of the Soulsbyville district in many cases contain a galena-like mineral which gives blowpipe reactions for lead and antimony. Copper and iron sulphurets, magnetic iron pyrite or pyrrhotite, and blende are abundant. The vein of the Black Oak quartz mine is accompanied by a dark, fine grained slaty rock called "slate" by the miners. This in thin section is seen to contain a large amount of fibrous green hornblende in ragged prisms lying at all angles,

* 11th Ann. Rep. State Mineralogist of California, p. 222.

and in radiating tufts, and is presumably an altered dike rock, perhaps a fine grained diorite. There is also a fine grained dike? rock next to the vein of the Platt and Gilsen mine, which contains a good deal of a brownish mica, specks of iron disulphide and chlorite in minute veins. This rock is also called "slate" by the miners. The ore of the Hyde mine which is also in granite in the Soulsbyville district, is free milling. It contains the same sulphurets as the other mines above mentioned but in smaller amount.

In the West Point mining district, the ore contains abundantly ordinary iron and copper sulphides and magnetic iron pyrite or pyrrhotite. Cutting the vein of the Lockwood mine are dikes of a fine grained diorite of the camptonite series. The vein was said to have been richer where cut by these dikes.

To the north of Merrimac in Butte County, similar dikes accompany some of the gold quartz veins in the granite.

Gold in albite.—As is well known free gold usually occurs associated with quartz as a gangue. Instances are on record, however, of its occurrence in various materials, as talc, calcite, etc. Recently a series of specimens was sent to the writer by Mr. Leo Von Rosenberg of New York city, from the Shaw mine in Eldorado county, about four miles southwest of Placerville. This deposit occurs in clay slates associated with a dike or dikes of a feldspathic rock, which appears to be devoid of bisilicates. Judging from the specimens forwarded, the dike rock is more or less decomposed, and is at some points replaced by secondary white feldspar, which at other points cuts the dike rock in little seams. This feldspar is well crystallized, and with the aid of a lens striations may be noted on the crystals. In thin section these feldspars are seen to be twinned polysynthetically with extinctions proper to albite, and a partial chemical analysis by Dr. Hillebrand of the U. S. Geological Survey shows that it contains soda, no lime, and about 19 per cent of alumina. It is therefore albite. In two specimens of this crystallized albite there is free gold. Another interesting specimen is of a dark fine grained rock which appears to be an aphanitic form of the dike-rock in a seam of which free gold with a little calcite has been deposited.

The following is a partial analysis by George Steiger of the feldspar of the grayish-green dike rock forming part of the Shaw mine lode.

(No. 452 Sierra Nevada collection.)

Alumina	about 20·00
Lime	·49
Potassa	1·15
Soda	8·72

This would indicate that the feldspar of the dike rock is also albite although not so pure as the secondary albite that occurs in veins cutting the dike rock.

The feldspathic lode of the Shaw mine is cut by little veins of quartz, but judging from the specimens sent these are not very abundant, and do not seem to be connected with the deposition of the gold.

The quartz veins cut the veins of secondary albite showing that they were formed later than the albite. In one specimen there seemed to be an intermingling of quartz and albite, pointing to contemporaneous deposition. But in thin section, the idiomorphic albite crystals were plainly seen to be enclosed in the quartz, as if there had been a little fissure, the walls of which were coated with albite crystals and the open spaces in the middle between the albite crystals later filled in with quartz. All of the material of the lode, except perhaps the quartz, contains iron disulphide scattered through it in minute cubes, and calcite in little rhombs and particles.

Orofino gold mine.—One and a half miles northeast of Mount Aigare in Eldorado county on the west side of Big Cañon creek is a dike of rock about 1500 feet long with a nearly north and south strike but curving to the southwest at the south end. This dike is much broken up, and re-cemented into a breccia. One of the specimens of the dike collected there by the writer in 1889 is a quartz-diorite, containing specks of iron disulphide and calcite; another specimen which seemed to grade over into the diorite is composed of a plagioclase feldspar probably albite, calcite, and grains of iron disulphide, and strongly resembles in thin section the vein material of the Shaw mine. This last specimen has a brecciated structure. It is auriferous and is the ore of the mine known as the Orofino gold mine. The country rock of the mine is clay slate, the same belt as at the Shaw mine, and is probably Carboniferous in age.

The gold deposits of both the Shaw and the Orofino mines are of such an unusual nature as to deserve further investigation.

Petre's River mine.—One mile northwest of the town of Mokelumne Hill in Calveras county on the north bank of the Mokelumne river is a quartz mine, owned by Mr. R. W. Petre. There are here two quartz veins which have a northwesterly strike and dip southwesterly about 80°. The veins are very irregular in width opening out into lens-shaped bodies, and quickly pinching out again. Mr. Petre stated that one of these lenses contained $10,000 in gold, but that most of the quartz was of low grade. The country rock of the mine is a quartz-diorite. Some granite schistose material occurs along

the main veins. A microscopic examination of this shows that it is practically a chlorite-schist. It is composed of a schistose aggregate of minute grains of feldspar, with much chlorite, and calcite. This schist is doubtless an attrition product, formed by movement along the walls of the vein. In one part of the vein there is a good deal of a hard white material, which the microscope shows to be largely feldspar, presumably albite. The feldspar occurs in unstriated interlocking grains with occasional twinned prisms. There is a good deal of calcite, pyrite, and muscovite, and foils of a green chloritic mineral. In the quartz-diorite country rock near the vein are a number of rounded bodies of calcite, some three feet in diameter. This calcite was doubtless deposited in pre-existing cavities.

Gold with barite.—Mr. W. Lindgren* has described an interesting deposit at Pine Hill, Cala. In a zone of decomposed and kaolinized diabase are irregular veins or seams of barite with which gold is associated. Other similar associations are noted.

Mr. Wirt Tassin of the U. S. National Museum kindly called my attention to a paper by Henry Louis† on the mode of occurrence of gold. Mr. Louis gives a list of 77 species of minerals, some of which however are formed from the decomposition of previously existing minerals that are found in gold veins. Only one feldspar is noted, orthoclase from Colorado. The exact locality is not given. The author further says that while iron pyrite is an almost universal constituent of gold quartz veins, marcasite seems never to occur; and in conclusion suggests that the gold and quartz have been simultaneously deposited in veins from alkaline solutions.

Gold in calcite.—The Yellowstone mine at Bear valley, Mariposa county, is in diabase. The course of the vein is about W. 20° S. The ore occurs in the altered diabase broken up along the vein and re-cemented with quartz and calcite. A specimen of the ore presented by the superintendent, Mr. McDonald, to the National Museum shows spots of free gold at numerous points associated with white quartz and calcite. According to Mr. Hall, the former owner, in the upper workings a good deal of the gold occurred in calcite.

In the collection of the U. S. National Museum there is a specimen of calcite in which are threads of native gold. This was collected by Dr. W. H. Melville from the Bannock mine, Montana.

Gold with quartz in rhyolite.—One mile east of Onion valley in Plumas county, California, is a dike of rhyolite in

* This Journal, vol. xliv, 1892, pp. 92–96.
† Mineralogical Magazine, vol. x, 1893, pp. 241–247.

the auriferous slate series at the headwaters of Poorman creek, in a decomposed portion of which free gold occurs associated with little veins of quartz. As the gulch was very rich below this dike, it is possible that much of it came from the rhyolite. The occurrence is remarkable inasmuch as the rhyolite is probably of Tertiary age. This rhyolite is a white rock with abundant foils of a brown mica, and phenocrysts of sanadine and plagioclase with a few rounded quartzes in a microcrystalline groundmass.

Gold with cinnabar.—Besides the Blue Wing vein locality previously noted, gold occurs with cinnabar in a vein in diabase near Coulterville. The cinnabar is in large fine crystals. The mine is the property of C. L. Mast and is the one referred to by Becker.*

Free gold is found with cinnabar in the Manzanita mine in Colusa county in the Coast ranges in metamorphosed strata containing *Aucella piochi* Gabb; a fossil characteristic of the lowest Cretaceous.

ART. LX.—*A recent analysis of Pele's Hair and a Stalagmite from the lava Caves of Kilauea;* by A. H. PHILLIPS.

THE Pele's Hair was collected the past summer by Prof. Libbey during his recent trip to Hawaii. In both cases the finely powdered substance was dried at 100° C. On subsequently igniting the stalagmite became reddish and increased in weight due in all probability to the oxidation of the ferrous iron present.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	P_2O_5	CaO	MgO	Ma_2O	K_2O	Total.
Peles' Hair,	50·76	14·75	2·89	9·85	·41	·26	11·05	6·54	2·70	·88	100·09
Stalagmite,	51·77	15·66	8·46	6·54	·82	--	9·56	4·95	2·17	·96	100·89

The above analysis of Pele's Hair does not differ in any essential respect from that of Prof. O. D. Allen's,† but there is quite a large difference, both in the amount of alumina and potassa when compared to that of D. E. Cohens.‡ In the latter the alumina is only 9·14 per cent while the potassa is 3·06 per cent. These variations may be explained by the fact that, the fused lava charge of Kilauea is drawn off every few years by some subterranean channel and is again slowly refilled by a new supply.

The stalagmite is of the kind, so characteristic of the lava caverns of Kilauea and Mount Loa; while it has not been pos-

* Quicksilver Deposits, p. 383. † This Journal, 1879, III, xviii, p. 134.
‡ Quoted in Characteristics of Volcanoes, Dana, p. 348.

sible to find an analysis of a stalagmite with which to compare it, but in comparison with that of Pele's Hair, their similarity is very striking, differing from it not as much as do the several analyses of Pele's Hair do from each other. With the one exception, the iron in the stalagmite has been further oxidized, but even here the FeO exists in larger proportions as compared to the Fe_2O_3 than it does in magnetite and could still undergo oxidation to a considerable extent before it would exist or could be represented by the formula Fe_3O_4. Both from the physical character and chemical composition of these stalagmites, it seems impossible to think of them as being formed from solution alone. Some other cause must be sought for as the chief factor in their formation. They are almost without exception, both stalactites and stalagmites, porous and vesicular though being quite solid on the surface, while the stalactites are of nearly the same diameter throughout their entire length, which in some cases may reach thirty inches. Two characters very hard to find if at all in a stalactite known to be formed from solution without doubt.

The stalagmites in particular are suggestive of fused drops, which falling one on the other are at the time sufficiently plastic to be quite firmly welded together and congealed in a slightly drooping position, while gases liberated internally and being held there by the more viscous external portions of the drop, would form vesicles. Then too the condition of iron oxides point to some other mode of formation than that of pure solution, for certainly a solution of ferrous iron flowing in a thin film down the sides of a stalactite, then dropping from its point to the stalagmite would be oxidized to a far greater extent than this analysis shows. Unless surrounded by an atmosphere strongly reducing in character it would pass to ferric iron. True the analysis by J. C. Jackson given by Brigham contains no ferrous iron, but then this was of a solid stalactite, which may have been one of solution.

Again any solvent must show some selective character in the substances it dissolves, but here all constituents are carried down to the stalagmite in the same proportion as they exist at least in Pele's Hair. I hope soon to be able to draw a closer comparison by making, as soon as the material can be obtained, an analysis of a stalactite and the lava above it from which it is supposed to have originated by solution. In all probability they will show no marked differences but everything will be found in the same proportions in the stalactite as in the lava. What the principal factor in the production of their peculiar formation is; if they are not formed while still in a fused or plastic condition. It certainly is other than by solution alone.

John C. Green School of Science, Princeton, N. J., Mar. 19th, 1894.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Mass of a Liter of Normal Air.*—The mass of oxygen in the air at Sorbonne has been found by Leduc to vary from 23·14 to 23·20 per cent; and since this difference corresponds to a tenth of a milligram in the mass of a liter of air, he regards it as useless to attempt any higher degree of accuracy in such determinations without at the same time determining the composition of the air examined. He finds that the mass of a liter of the average air at Paris, at 0° and 760^{mm} is 1·29315 gram. Defining normal air to be air collected on a plain in calm weather at a distance from a town, which contains a little more than 23·2 per cent of oxygen by mass or almost precisely 21·0 per cent by volume, the author finds that the mass of a liter of such air at 0° and 750^{mm} is 1·2932 grams; and at 0° and under one c. g. s. atmosphere, 1·2758 grams. In estimating the densities of gases, he prefers to take nitrogen as the standard because, not only is it readily procurable in a state of purity but it has a density so nearly that of air that no appreciable error is caused by the presence of a small quantity of air in the apparatus. The mass of a liter of nitrogen at Paris under normal conditions is 1·2570 grams; its mass under a pressure of one c. g. s. being 1·24006 grams.—*C. R.*, cxvii, 1072, December 1893. G. F. B.

2. *On the Preparation of Nitrogen monoxide.*—It has been observed by W. Smith that a mixture of ammonium sulphate and sodium nitrate, kept at 215° for two or three hours, decomposes for the most part into sodium sulphate and ammonium nitrate; and further that if the mixture be more strongly heated, nitrogen monoxide begins to be evolved at 230° and comes off quite rapidly at 240° to 250°. A little ammonia is evolved however during the heating, the more ammonia being lost the longer the mixture is kept between 220° and 230°. Consequently if at the outset the mixture has been made in molecular proportions, this evolution of ammonia leads to the setting free of some of the higher nitrogen oxides towards the end of the reaction. To remedy this the author increases the proportion of ammonium sulphate; and now the mixture having 5 per cent additional sulphate, yields a larger quantity of nitrogen monoxide than is obtained ordinarily from the equivalent quantity of ammonium nitrate. The evolution of gas goes on more regularly than with ammonium nitrate itself which at 240° is liable to decompose with almost explosive violence.—*J. Soc. Chem. Ind.*, xii, 10, January 1893. G. F. B.

3. *On the Conversion of Yellow Phosphorus into the Red variety.*—When yellow phosphorus is crystallized from the ordinary organic solvents of this substance, best by cooling a hot solution of it, it is generally conceded that the crystals are

dodecahedrons. RETGERS however has experimented with essential oils used as solvents and has not been able to confirm the production of dodecahedrons under these circumstances. Indeed it would appear that under certain conditions the yellow variety of phosphorus is amorphous; as when it is obtained in a thin layer between two slips of glass. With reference to the action of heat on this substance, the author observes that when heated phosphorus passes through three stages of change. In the first it becomes yellow to brown, though still remaining regular and transparent. In the second a granular, undoubtedly crystalline segregation occurs, red opake phosphorus being formed. And in the third there is produced a graphitic chocolate-colored phosphorus. The first production of a true modification occurs at the second stage. Light was observed to produce a similar series of changes, these changes not being confined to the surface. The character of the white crust which forms on phosphorus when submerged in water, the author has not finally determined though he considers it a hydrate rather than a different modification. Since the properties of an amorphous modification so far as known, are never intermediate between those of two crystalline modifications, this rule would be violated if red phosphorus were amorphous; for the density of red phosphorus is 2·148 and that of yellow phosphorus is 1·826; while that of the chocolate-colored hexagonal variety is 2·34.—*Zeit. Anorg. Chem.*, v, 211, October 1893. G. F. B.

4. *On the Behavior of Carbon, Boron and Silicon in the Electric Furnace.*—In continuing his experiments with the electric furnace MOISSAN has now subjected carbon, boron and silicon to the action of the electric arc. At a somewhat high temperature, the diamond under those circumstances becomes incandescent and swells up without melting, covering itself with black particles entirely consisting of hexagonal plates of graphite easily convertible into graphitic oxide. When placed in a small carbon crucible and acted on by an arc produced by 70 volts and 400 amperes, the diamond first breaks up into fragments along the planes of cleavage and then swells up as the temperature rises and is completely converted into graphite. Hence it appears that the stable form of carbon is graphite, even at the temperature of only a moderately intense electric arc. If heated in a carbon enclosing vessel, in a jet of oxygen and hydrogen gases, however, the diamond is sometimes covered with a black adhering mass which slowly dissolves in a mixture of nitric acid and potassium chlorate but which is not graphite. Amorphous boron volatilizes without fusion in the electric arc, the ends of the electrodes being converted into semi-crystallized boron carbide. Silicon thus treated melts and then boils, covering the ends of the carbon electrodes with pale green crystals of carbon silicide.

This carbon silicide Moissan has studied more carefully. He finds that when carbon is dissolved in fused silicon in a wind furnace, crystals of carbon silicide several millimeters in length

can be obtained; showing that these two elements combine readily in a fused medium at 1200° to 1400°. This compound can be produced much more easily however by heating a mixture of 12 parts of carbon and 28 parts of silicon in the electric furnace, the resulting product being treated first with a mixture of nitric and hydrofluoric acids and then with one of nitric acid and potassium chlorate. Generally the crystals are yellow; but when the operation is conducted with silicon as free as possible from iron, in a closed crucible, the crystals are transparent and sapphire blue in color. Carbon silicide has the composition CSi, has a density of 3·12, and acts strongly on polarized light. The crystals are very hard and scratch chrome steel and rubies. The silicide is not affected by oxygen or by sulphur vapor at 1000°, though chlorine decomposes it at 1200°. Fused niter, or potassium chlorate, boiling sulphuric, nitric or hydrochloric acids, aqua regia and even mixtures of nitric and hydrofluoric acids do not attack it. It is gradually converted by fused potassium hydroxide into potassium carbonate and silicate.

The latest form of Moissan's electric furnace consists of a rectangular block of Courson limestone, containing a large rectangular cavity, lined with alternating plates of magnesia and carbon about a centimeter thick, the magnesia being in contact with the limestone and the carbon lining the interior of the cavity. A lid, also of alternating plates of magnesia and carbon covers the cavity, a block of the same limestone resting upon the lid. The electrodes, which are both movable, pass through slots cut in opposite sides of the furnace. A carbon tube one or two centimeters in diameter passes through the furnace at right angles to the electrodes being so arranged as to be a centimeter below the arc and the same distance above the bottom of the cavity. When this tube is inclined at an angle of about 30°, the furnace may be made to work continuously, the reducible material being introduced at the upper end and the product of reduction being drawn off at the lower. With a current of 600 amperes and 60 volts, two kilograms of fused metallic chromium can be obtained in about an hour, the metals being received in a crucible made of chromic oxide. The metal is white and very hard, is finely granular and takes a high polish. In this furnace both silicon carbide and vanadium carbide can be easily obtained by directly combining the vapors of silicon and vanadium with the vapor of carbon. The plates of magnesia are prepared by heating the basic carbonate, digesting with ammonium carbonate, again strongly heating and then compressing into blocks.—*C. R.*, cxvii, 423, 425, 679, Sept., Nov. 1893. G. F. B.

5. *On Crystallized Silicon carbide or Carborundum.*—Experiments somewhat analogous to those of Moissan have been made by MÜHLHÄUSER. By mixing together fine coke, sand and salt, packing the mixture round a carbon rod in an oblong box of fire brick, and connecting the ends of the carbon core with the terminals of a transformer, the entire mass could readily be raised to a

white heat. After the reaction had ceased, a transverse section showed that surrounding the carbon rod, was (1) a zone of adhering graphite, (2) a zone of crystallized silicon carbide, (3) a zone of amorphous silicon carbide, (4) a zone containing pockets of fibrous material, (5) a zone of the original mixture only slightly altered and, (6) a hard external layer consisting almost entirely of salt. The graphite had all the properties of the natural mineral, but had the crystalline form of the silicon carbide; indicating that the latter is first formed and then loses its silicon by volatilization. The outer portion of this graphite zone gave 33·71 per cent of variously colored crystals containing 30·49 per cent of silicon and 68·26 of carbon. The second zone constituted the chief product of the reaction. On breaking up the mass in a mortar, the separate crystals were obtained, bluish or yellowish-green in color, and varying in size from microscopic dimensions to several millimeters in diameter. To purify it, it was heated to dull redness in oxygen, boiled with potash solution, washed, digested with hydrochloric acid and finally treated with hydrofluoric acid. It then has the composition SiC, and a density of 3·22 at 15°. Under the name of *carborundum* it has come into use in the arts to replace emery.—*Zeit. Anorg. Chem.*, v, 105, October 1893. G. F. B.

6. *On Antimony-Blue.*—According to SEBOR, antimony-blue may be prepared by dissolving antimony sulphide in concentrated hydrochloric acid, and, after filtering, adding to the boiling liquid a concentrated solution of potassium ferrocyanide and some potassium chlorate or nitric acid. The precipitate is dried at 100°. Another antimony-blue may be obtained by mixing antimony chloride and potassium ferrocyanide and adding a large quantity of water. When prepared in this way however, it contains some basic antimony chloride. A sample of pure antimony-blue yielded on analysis Fe 30·28, Sb 2·422, H_2O 5·828, Cl 0·712, O 0·323, and Cy 60·435 per cent. Antimony-blue is insoluble in cold hydrochloric, sulphuric and nitric acids, and yields hydrogen cyanide when boiled with hydrochloric or sulphuric acid. Warm dilute sodium and potassium hydroxides attack it, and nitric acid on heating converts it into a grayish-green compound. Unlike Prussian blue it is not soluble in a solution of an oxalate or a tartrate.—*Chem. Centr.*, ii, 318, 1893; *J. Chem. Soc.*, lxvi, i, 3, Jan. 1894. G. F. B.

7. *On the Nitro-metals.*—The researches of SABATIER and SENDERENS upon the nitro-metals have been continued and they now report the discovery of nitro-cobalt, nitro-nickel and nitro-iron. Nitro-cobalt is best prepared from cobalt reduced at a low temperature, by passing over it nitrogen peroxide suitably diluted with nitrogen. Black nitro-cobalt CO_2NO_2 is thus produced, upon which water acts vigorously, but gives less nitrogen dioxide than nitro-copper; producing a solution of cobalt nitrate, containing very little nitrite. Heated in nitrogen nitrous fumes are evolved and then decomposition takes place with almost explosive

violence. It explodes when mixed with combustible matter. Nitro-nickel is similarly prepared and has similar properties. Nitro-iron is more difficult to prepare, deflagration taking place after the absorption of a portion of the peroxide.—*Bull. Soc. Chim.*, III, ix, 669, Sept. 1893. G. F. B.

8. *On the Preparation of Ethyl ether.*—It has been pointed out by KRAFFT that in the preparation of ether by means of sulphuric acid, the acid is partly reduced to sulphurous acid by the alcohol. Since the aromatic sulphonic acids are more stable in presence of alcohol, the author proposes their use for the continuous etherification of alcohol. Using ethyl alcohol and benzene-sulphonic acid for example the reaction is: (1) $PhSO_2.OH + EtOH = PhSO_2.OEt + H_2O$; and (2) $PhSO.OEt + EtOH = PhSO_2.OH + Et_2O$. In practice the alcohol is dropped on the benzene-sulphonic acid heated to 140°. Methyl-propyl ether was thus produced and boiled at 36·6°–37·4°.—*Ber. Berl. Chem. Ges.*, xxvi, 2829, Dec., 1893. G. F. B.

9. *Line Spectrum of Oxygen.*—M. EISIG has taken up the subject anew with the aid of a Rowland concave grating and with Rowland's map of the solar lines. An analysis of the work of Schuster, Deslandres, Trowbridge and Hutchins, and Hartley and Adeney is made, and the author is forced to the conclusion that there is no positive evidence that oxygen exists in the sun.—*Ann. der Physik und Chemie*, No. 4, 1894, pp. 747–760. J. T.

10. *Lilienthal's experiments on flying.*—With the conviction that the flight of birds is an art which must be carefully studied, LILIENTHAL has practised himself in taking advantage of the remarkable fact discovered by Langley and by himself that with certain angles of inclination of wings to the direction of the wind, not only does the horizontal component of the wind disappear, but even may become negative, that is the fans which act as wings fly against the wind and can be raised by it. He accordingly selects a gentle incline free from woods or other obstruction to the free movement of the wind. This incline was usually not more than 10 or 15° to the horizon and ran against the direction of the wind. After some experience Lilienthal was enabled to soar distances of 120 to 150 meters against the wind. Professor A. du Bois Reymond states that after only four or five trials he was enabled to take leaps of from 15 to 20 meters long. Lilienthal by means of stronger winds has been enabled to soar in circles like those of birds similar to the hawk. If this practise of soaring is introduced as a sport, its use and the accumulated experience of many young athletes, may lead to our learning the art of flying. Prof. du Bois Reymond calls attention, in this connection, to the great skill that has been acquired in the art of balancing oneself on bicycles and similar machines.—*Physical Society of Berlin*, Dec. 15, 1893. *Ann. der Physik und Chemie*, No. 4, 1894, p. 42. J. T.

11. *Apparatus for the demonstration of Ampere's laws.*—In order to avoid the disturbances which arise from the use of mer-

cury cups, in the ordinary form of lecture apparatus for showing Ampere's laws, RAPS has devised a system of two rolling metallic contacts, by means of which the electric current can be led to and away from the model. To show the applicability of the apparatus he instances this case. A solenoid of 15^{cm} diameter, 40^{cm} in length, with 70 turns of aluminum wire, with a current of 6 amperes, places itself in the magnetic meridian.—*Physical Society of Berlin*, Oct. 20, 1893. *Ann. der Physik und Chemie*, No. 4, 1894, p. 29. J. T.

12. *Magnetisation of Iron by rapid Electrical Oscillations.*—KLEMENCIC, at a recent meeting of the Kaiserliche Akademie der Wissenschaft of Vienna, read a paper on this subject. The value of μ, the magnetic permeability was determined by a heat method. The following are some of the values obtained for μ: Soft iron 118, soft steel wire 106, hard steel wire 115, soft Bessemer steel 77, hard 74, nickel 27. These values agree fairly well with those of Rayleigh and Bauer for very feeble magnetising forces. It appears that Bauer and Rayleigh's results for longitudinal magnetism also apply to circular magnetism.—*Nature*, April 26, 1894, p. 607. J. T.

II. GEOLOGY AND MINERALOGY.

1. *On the Straining of the Earth resulting from Secular Cooling;* by CHARLES DAVISON. Read before the Royal Society, London, January 10, 1894. (Abstract.)—If the coefficient of dilatation (e) and the conductivity (k) are constant for every point within the earth, and if the temperature (V) was initially the same throughout, the depth of the surface of zero-strain after 100 million years is 2·17 miles, the total volume of the crust folded and crushed above that surface is about 184,500 cubic miles, and the mean thickness of the crushed rock spread over the whole surface of the earth is 4·95 ft. (taking e=0·0000057), k=400, V=7000° F.). The smallness of these figures has been claimed by some geologists as a new and strong argument against the contraction theory of mountain evolution.

In the present paper the problem is reconsidered on the supposition that the coefficient of dilatation is not constant, but increases with the temperature, the change in the former varying as the corresponding change in the latter. It follows, from experiments made by Fizeau, that, for a rise of one degree in temperature, the coefficient of dilatation increases on an average by about 1/888. Adopting this value, and taking the other constants as above, it is found that, after 100 million years, the depth of the surface of zero strain is 7·79 miles, the total volume of crust-folding about 6,145,000 cubic miles, and the mean thickness of the layer formed by spreading it over the whole earth 164·7 ft.

If the conductivity increases with the temperature, or if the material which composes the earth's interior be such that the conductivity and coefficient of dilatation are greater in it than in the

surface rocks, or if initially the temperature increased with the depth, the figures given in the preceding paragraph must be still further increased. It follows, therefore, that calculations as to the alleged insufficiency of the contraction theory to produce mountain ranges are at present inadmissible.

2. *Appendages of Trilobites.*—As the result of study of some specimens of *Triarthrus Becki*, C. D. WALCOTT has prepared a *note on some appendages of the trilobite* with a plate illustrating the structures and diagrammatic restorations of the thoracic limbs. Mr. Walcott shows the antennæ to arise from the under side of the head near the postero-lateral angle of the hypostoma. He would make classes of the Trilobita and Merostomata; the Trilobita and Phyllopod branches diverging from a common Crustacean base of precambrian time, the descendants of the Phyllopod branch being the modern Crustacea, while the Trilobita became extinct at the close of the Paleozoic.—*Proc. Biol. Soc.*, Washington, vol. ix, pp. 89–97, Pl. I, March 30, 1894.

3. *Geological Surveys in Alabama;* by EUGENE A. SMITH: The Journal of Geology, vol. ii, pp. 275–287, April–May, 1894.—A brief synopsis of the history of the geological work done in the State of Alabama is given in this article by the present State Geologist.

4. *Tertiary Tipulidæ, with special reference to those of Florissant, Colorado;* by S. H. SCUDDER (Proc. Amer. Philos. Soc., vol. xxx, 83 pp., Plates I–IX.—In this memoir, presented on the occasion of the celebration of the 150th anniversary of the foundation of the American Philosophical Society, Dr. Scudder has figured and described a series of beautifully perfect crane-flies (Tipulidæ) from the Tertiary beds of Florissant, Colorado. Most of the specimens show the venation of the wings and their most delicate markings, and on some of them the fragile legs, thin hairs, the antennæ and even the facets of the compound eyes are preserved.

Some of the more important conclusions reached as a result of the study of this interesting fauna are as follows: The general facies of the Tipulid fauna of our western tertiaries is American and agrees best with the fauna of about the same latitude in America; all the species are extinct and the fauna is presumably of Oligocene age; no species are identical with described European Tipulidæ; eight out of the fifteen genera are extinct; all the existing genera (except one, Cladura) in the American tertiaries are genera common to the north temperate zone of Europe and America, and are either confined to these regions or the vast proportion of their species are so confined, indicating a similar climate, at least there is no certain evidence of a warmer climate.

W.

A paper by the same author on the *American Tertiary Aphidæ*, with several beautiful plates, is contained in the forthcoming 13th Ann. Report of the Director of the United States Geological Survey.

5. *Shawangunk Mountain.*—Under this title N. H. DARTON gives his interpretation of the structure and topography of the mountain, the surface being mainly the expression of plications of the thick Shawangunk grit overlying the soft shales of the Hudson River epoch, whose erosion has determined the more abrupt eastern slopes of the mountain mass.—*The National Geographic Magazine*, vol. vi, pp. 23–34, Pls. 1–3, March, 1894.

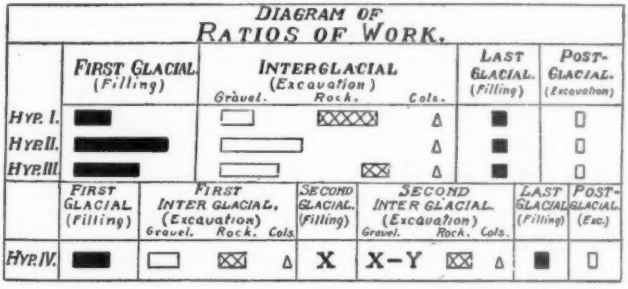
6. *Geological Section of the Alps.*—A. ROTHPLETZ has published a report which will be of much value to geologists crossing the Alps, or wishing to gain a vivid idea of their structure. In "*Ein geologischer Querschnitt durch die Ost-Alpen nebst anhang über der sog. Glarner doppelfalte* (pp. 268, 2 plates and 115 figures, Koch, Stuttgart, 1894), a section is run from near Tölz across to Bassano nearly along the meridian of Munich, 260 kilometers in length. A topographical map of the region is accompanied by a long colored profile section (over 11 feet in length) on a scale 1 : 75000, exhibiting clearly the general structure. The details of structure are well elaborated by figures distributed throughout the text.

7. *The Arkansas Coal Measures.*—In a paper *on the Arkansas Coal Measures in their relations to the Pacific Carboniferous Province*, J. PERRIN SMITH has made an analysis of the faunas of the several divisions of the Arkansas Coal Measures and has discussed their relations to the Carboniferous and Permian deposits of the Pacific province of North America and of China, India and Brazil, explaining in an interesting way the geological events which account for the correlations of the organisms of the several regions.—*Journ. Geol.*, vol. ii, pp. 187–204, Feb., March, 1894.

8. *The Crinoidea of Gotland.* Pt. I. *The Crinoidea inadunata;* by F. A. BATHER, pp. 182, Plates I–X. Kongl. Svenska Vetenskaps-Akademiens Handlingar, vol. xxv, No. 2, Stockholm, 1893.—This work is not only a thorough review of the species of Angelin's "Iconographia," but after a careful study of rich collections made by Angelin and now in the Stockholm Museum, the author has with exquisite delicacy developed the minute structure of the species studied, and with the assistance of an artist equally accurate with himself (Mr. J. Liljevall) has produced a monograph thoroughly up to the needs of modern science. Among the more valuable additions to knowledge are the reconstruction of the genus *Pisocrinus*, determining its true relations with other Monocyclica; the revision of the genera of Calceocrinidæ based upon a full delineation of the skeletal elements; the account of the morphology of the genus *Herpetocrinus* (=*Myelodactylus*); the revision of the Inadunata, resulting in the abolishing of the suborders Larviformia and Fistulata, and the erection of the divisions Monocyclica and Dicyclica separated according to the presence or absence of infrabasals. The Dicyclica are also revised as the result of fuller knowledge of their ventral and anal structures. H. S. W.

9. *Die Vorwelt und ihre Entwickelungsgeschichte;* by ERNST KOKEN, pp. 654, 1893.—Professor Koken has produced an elaborate treatise on the development of the earth and its inhabitants, beginning with a discussion of the interior condition of the earth and of the crust, devoting a chapter to mountain building, another to estimates and notions of time in geology, and in the remainder of the book elaborating step by step the development of the formations, by deposition, growth of continents by earth movements, and by surface shaping up to the present condition of the earth. Under each system is added a general review of the history of organisms for the period discussed as faunas and floras, the species being named but not described, with account of their distribution and relations to other faunas and floras and to those which have preceded and succeeded them. A great amount of information is brought together about geology and paleontology, carefully arranged in a systematic manner, with running commentary by the author.

Correction.—In the paper entitled "*Further Studies of the Drainage Features of the Upper Ohio Basin*" in the April number of this Journal, a serious error occurs in figure 5, page 282, which the authors desire to correct. In the second column of the diagram, which represents interglacial excavation, the unit of filling was employed in draughting, instead of the unit of excavation, thus doubling the amount, since it happens that the valley-filling of late glacial gravels was just about twice the volume of the postglacial erosion. The error crept in during the re-drawing and reduction of the diagram for the Journal, and escaped detection until some time after publication. It did not appear in the original diagram used at the Boston meeting of the Geological Society of America, nor in the computation of the authors. The diagram is herewith reproduced in the corrected form.



T. C. CHAMBERLIN.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Watson Gold Medal of the National Academy of Sciences.*—This medal, which was awarded 1888, April 19, to Dr. EDWARD SCHÖENFELD of Bonn, and which was conferred 1891, April 22,

upon Dr. ARTHUR AUWERS of Berlin,—was unanimously voted 1894, April 17, to Dr. SETH C. CHANDLER of Cambridge, for his investigations and discoveries concerning the Variation of Latitude, and his researches relative to Variable Stars.

2. *The use of Governmental Maps in School;* by WM. M. DAVIS, C. F. KING and G. L. COLLIN, pp. 65 (Henry Holt & Co.), 1894.—This is a handy descriptive list of some of the more useful maps of the United States, with brief directions for obtaining them, grouped under the following heads, the geological survey, the Coast and Geodetic Survey, the Mississippi River Commission, the Missouri River Commission, the Survey of the Northern and Northwestern Lakes, the State Topographical Surveys, the Weather Bureau and the Hydrographic office. Though primarily designed for schools, the Report will be useful to all persons interested in the geographical features of the country.

W.

3. *National Academy of Sciences.*—The following is a list of the papers presented at the April meeting held at Washington, April 17 to 20:

G. L. GOODALE: Histological Characteristics of Certain Alpine Plants. Corrosions by Roots.

GEORGE C. COMSTOCK: An Investigation of the Aberration and Atmospheric Refraction of Light, with a Modified Form of the Lœwy Prism Apparatus.

JOSEPH LE CONTE: Biographical Memoir of John Le Conte.

A. AGASSIZ: The Coral Reefs of the Bermudas. The So-called Serpulæ Reefs of the Bermudas. The Bathymetrical Extension of the Pelagic Fauna.

M. CAREY LEA: New Method of Determining the Relative Affinities of Certain Acids.

A. M. MAYER: On the Change of Young's Modulus of Elasticity with Variation of Temperature, as Determined by the Transverse Vibration of Bars of Various Temperatures. On the Production of Beats and Beat-tones by the Covibration of two sounds, so high in pitch, that when separately sounded they are inaudible. On the Motions of Resonators and Other Bodies Caused by Sound Vibrations, with Experimental Illustrations; also a Reclamation.

S. C. CHANDLER: On Late Researches on the Variation of Latitude.

S. P. LANGLEY: On the Infra-red Spectrum. The Internal Energy of the Wind.

J. S. BILLINGS: The Bacteria of River Water. The Influence of Light Upon the Bacillus of Typhoid, and the Colon Bacillus.

T. C. MENDENHALL: Recent Gravity Instruments and Results.

THEO. GILL: The Geographical Distribution of Fresh-water Fishes.

C. S. HASTINGS: Note on a Possible Increase in the Ultimate Defining Power of the Microscope.

OBITUARY.

SAMUEL WHITE BAKER, the African explorer, died Jan. 20, 1894, at the age of 73.

VERNON LOVETT CAMERON, another of the leaders of discovery in Africa, died March 26, 1894, at the age of 50.

WILLIAM PENGELLY, the English Archæologist, died March 16, 1894, at the age of 82.

GEORGE POUCHET, the author in 1858 of "De la pluralité des races humaines," died in March, 1894, aged 61.

CHARLES EDOUARD BROWN-SÉQUARD, the eminent French physiologist, died April 1, 1894, at the age of 77.

JOSEPH DE SZABO, geologist and mineralogist of Buda Pest, died April 10, 1894.

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3. HELVITE GROUP. Isometric, Tetrahedral.

366. **Helvite;** isometric; H=6–6.5; G=3.16–3.36; orthosilicate of manganese, beryllium and iron, with sulphide of manganese; $(Mn, Fe)_2(Mn,S)Be_3(SiO_4)_3$.

Achtaragdite, a pseudomorph, perhaps after Helvite.

367. **Danalite;** isometric; H=5.5–6; G=3.42; orthosilicate of iron, zinc, beryllium and manganese, with sulphide of zinc and iron; $(Fe, Zn, Mn)_2([Zn, Fe]_2S)Be_3(SiO_4)_3$.

368. **Eulytite;** isometric; H=4.5; G=6.106; orthosilicate of bismuth; $Bi_4(SiO_4)_3$.

369. **Zunyite;** isometric; H=7; G=2.875; a highly basic orthosilicate of aluminum; $(Al[OH,F,Cl]_2)_6Al_2(SiO_4)_3$.

4. GARNET GROUP. Isomeiric, Holohedral.

370. **Garnet;** isometric; H=6.5–7.5; G=3.15–4.3; an orthosilicate of one or more of the bivalent elements calcium, magnesium, ferrous iron or manganese, combined with one or more of the trivalent elements aluminum, ferric iron, chromium, or titanium; general formula, $\overset{II}{R_3}\ \overset{III}{R_2}\ (SiO_4)_3$.

1. Aluminum Garnet.

Sub-Species I. Grossularite; Calcium-Aluminum Garnet: $Ca_3Al_2(SiO_4)_3$; G=3.55–3.66. *Var.* (a) *Wiluite* is pale, gooseberry green; (b) *Essonite* or *Cinnamon-Stone* is cinnamon brown to wine yellow; *Hyacinth* belongs here; (c) *Succinite* is amber-colored; (d) *Romanzovite* is brown; (e) *Rosolite* or *Rose Garnet* is rose pink, from Mexico.

Sub-Species II. Pyrope; Magnesium-Aluminum Garnet; $Mg_3Al_2(SiO_4)_3$; G=3.70–3.75; color deep to dark red; when transparent it is called *Precious Garnet.*

Sub-Species III. Almandite; Iron-Aluminum Garnet; $Fe_3Al_2(SiO_4)_3$; G=3.9–4.2; color deep red to violet; when transparent it is called *Precious Garnet* or *Almandine Garnet;* if cut en cabochon, *Carbuncle;* when opaque and brownish-red it is called *Common Garnet.*

Sub-Species IV. Spessartite; Manganese-Aluminum Garnet; $Mn_3Al_2(SiO_4)_3$; G=4.0–4.3; color dark hyacinth to brownish-red.

2. Iron Garnet.

Sub-Species V. Andradite; Calcium-Iron Garnet; $Ca_3Fe_2(SiO_4)_3$; G=3.8–3.91. *Var.* (a) *Simple Calcium-Iron Garnet;* includes: 1. *Topazolite,* crystallized, lemon-yellow; *Demantoid* is in pebbles, grass- to emerald-green, and highly-prized as a gem; 2. *Colophonite* is granular, brownish, resinous; 3. *Melanite* is crystallized, black; *Pyreneite* is a grayish-black Melanite; 4. *Jelletite* is a green or yellowish variety in small crystals (from Switzerland); *Calderite* is massive (from India), one kind resembles Colophonite. (b) *Manganesian Calcium-Iron Garnet;* includes: 1. *Rothoffite* and *Allochroite,* massive and brown, yellowish or reddish-brown; *Polyadelphite* is brownish-yellow from Franklin Furnace; *Bredbergite* is from Sala; 2. *Aplome* is a dodecahedral, striated, brown to yellowish-green variety. (c) *Titaniferous Garnet;* graduates towards Schorlomite, $Ca_3(Fe,Ti,Al)_2([Si,Ti]O_4)_3$; color black. (d) *Yttriferous Calcium-Iron Garnet* or *Yttergarnet,* contains yttria.

3. Chromium Garnet.

Sub-Species VI. Uvarovite; Calcium-Chromium Garnet; $Ca_3Cr_2(SiO_4)_3$; H=7.5; G=3.41–3.52; color emerald-green, crystallized. *Trautwinite* is an impure variety.

371. **Schorlomite;** isometric; H=7–7.5; G=3.81–3.88; a titano-silicate of calcium, iron and titanium; $Ca_3(Fe,Ti)_2([Si,Ti]O_4)_3$. *Ivaarite* is probably identical, or a variety.

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